SALMON AND STEELHEAD HABITAT LIMITING FACTORS

WATER RESOURCE INVENTORY AREA 26

WASHINGTON STATE
CONSERVATION COMMISSION

FINAL REPORT

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EXECUTIVE SUMMARY

Introduction

Section 10 of Engrossed Substitute House Bill 2496 (Salmon Recovery Act of 1998), directs the Washington State Conservation Commission, in consultation with local government and treaty tribes to invite private, federal, state, tribal, and local government personnel with appropriate expertise to convene as a Technical Advisory Group (TAG). The purpose of the TAG is to identify habitat limiting factors for salmonids. Limiting factors are defined as "conditions that limit the ability of habitat to fully sustain populations of salmon, including all species of the family Salmonidae." The bill further clarifies the definition by stating, "These factors are primarily fish passage barriers and degraded estuarine areas, riparian corridors, stream channels, and wetlands." It is important to note that the responsibilities given to the Conservation Commission in ESHB 2496 do not constitute a full limiting factors analysis.

This report is based on a combination of existing watershed studies and knowledge of the TAG participants. WRIA 26 is located in Southwest Washington within portions of Lewis, Cowlitz, Skamania, Pierce, and Yakima Counties, and it includes the Cowlitz River systems and its major tributaries; the Coweeman, Toutle, Tilton, and Cispus Rivers (see Map 4 in Appendix A). The Cowlitz River enters the Columbia River at River Mile (RM) 68. Five stocks of anadromous salmon and steelhead, and coastal cutthroat trout return to the rivers. Spring and fall chinook salmon, chum salmon, and winter steelhead are listed as "threatened" under the Endangered Species Act by National Marine Fisheries Service. Coho salmon are listed as a candidate species, and coastal cutthroat are proposed for a "threatened" listing. For purposes of this analysis the WRIA 26 was separated into seven subbasins; Coweeman, Lower Cowlitz, Toutle, Mayfield/Tilton, Riffe Lake, Cispus, and Upper Cowlitz.

WRIA 26 Habitat Limiting Factors

The major habitat limiting factors common to most streams within WRIA 26 included:

- Mayfield, Mossyrock, and Cowlitz Falls dams form complete barriers to natural upstream migration and inhibit downstream migration. Over 300 miles of formerly productive habitat is either inaccessible or inundated by the reservoirs.
- Almost throughout WRIA 26, LWD abundance is below habitat standards. Adequate large woody debris in streams, particularly larger key pieces, is critical to developing pools, collecting spawning gravels, and providing habitat diversity and cover for salmonids.
- Riparian conditions are also poor within most of the basins. Loss of riparian function affects water quality, erosion rates, streambank stability, and instream habitat conditions.
- Water quality, especially high water temperatures, was identified as a major limiting factor within certain subbasins of WRIA 26.

- Both low flows that limit the rearing habitat and connectivity, and increased peak flows that alter instream habitat were considered significant problems in many subbasins.
- Most of the historic off-channel and floodplain habitat has been disconnected from the river by diking and hardening the channels and due to the 1980 eruption of Mount St. Helens. Loss of these off-channel habitats limits rearing and over-wintering habitat for juvenile salmonids within most subbasins.

WRIA 26 Recommendations for Addressing Limiting Factors

- Continue to monitor the impacts of the operation of the dams on salmonids and the success of the reintroduction efforts above the dams. Habitat restoration efforts above the dams will provide minimal benefits to salmon recovery without the development of sustainable wild runs through a successful reintroduction effort.
- Various land uses practices have had substantial impacts on habitat conditions for anadromous salmonids. The TAG suggests that critical areas ordinances be developed and/or updated to ensure protection of habitat for threatened and endangered species.
- Assess, repair, and where possible, decommission roads that are contributing chronic sediment to stream systems or that may fail and lead to landslides.
- Look for opportunities, both short- and long-term, to increase Large Woody Debris (LWD) supplies within stream systems.
- Riparian restoration is needed almost throughout WRIA 26. Long-term goals should include speeding the recruitment of mature conifers within riparian areas.
- Reduce excessive water temperatures in WRIA 26, especially within the Coweeman, Toutle, and Tilton Subbasins.
- Look for opportunities to augment stream flows and enhance rearing habitat in WRIA 26 during low-flow periods.
- Maintain at least 60% of vegetation within each subbasin in trees >25-years-old to increase hydrologic maturity and minimize the impacts to stream channels of increased peak flows.

Coweeman Subbasin Habitat Limiting Factors

Floodplain habitat within the lower 20 miles of the Cowlitz mainstem and within the lower Coweeman has been filled with Mount St. Helens deposits and disconnected from the river. Rearing and over-wintering habitat is very limited within the subbasin. Extensive logging and high road densities have left the subbasin hydrologically immature and subject to increased peak flows. High road densities and 69 miles of stream adjacent roads have also contributed excessive fine sediments to stream channels. Riparian conditions and Large Woody Debris (LWD) levels are generally poor throughout the subbasin, especially along the diked and developed lower reaches of the Cowlitz and the Coweeman rivers. Water quality is generally good within the Cowlitz, but lack of riparian cover has contributed to elevated water temperatures and turbidity in the Coweeman watershed.

Recommendations for addressing limiting factors in the Coweeman Subbasin:

- Assess, repair, and/or abandon road systems that are contributing sediment to stream channels (Rose Valley Road alone contributes 351 metric tons/year to the Coweeman).
- Look for opportunities to increase instream LWD in appropriate stream channels, and to increase and/or enhance limited off-channel and floodplain habitat in the lower Cowlitz and Coweeman rivers.
- Reduce land use activities within the subbasin that contribute to water quality problems (especially temperature and turbidity).

Habitats that need protection in the Coweeman Subbasin:

- Protect and enhance fall chinook spawning and rearing habitat within the mainstem from the mouth of Goble Creek (RM 11.4) to Baird Creek (RM 25.9);
- Protect floodplain habitat between RM 4 and RM 7.5 on the Coweeman River;
- Protect the most productive tributaries to the Coweeman subbasin including Mulholland, Baird, and Goble creeks (in order of priority).

Lower Cowlitz Subbasin Habitat Limiting Factors

Mayfield Dam has blocked upstream passage to approximately 80% of the historic habitat in the Cowlitz basin, altered the hydrology of the system, and blocked the movement of sediments to downstream habitats. An eight-mile section of the mainstem Cowlitz now provides most of the very limited spawning and rearing habitat for fall chinook and steelhead below the dams. Fish passage problems also occur on a number of tributaries in the subbasin.

The mainstem Cowlitz and many tributaries have experienced losses in key habitat areas and habitat diversity for most salmonid life-stages due to channel simplification and diking. Grazing, agriculture, forestry, and residential and commercial development have also substantially reduced riparian function, increased bank instability, and added fine sediments to many stream systems within the subbasin.

Recommendations for addressing limiting factors in the Lower Cowlitz Subbasin include:

- Continue to assess and mitigate for negative impacts to all species of anadromous salmonids from the operation of the dams.
- Restore and enhance a number of side channels below the dams that provide critical spawning and rearing habitat for fall chinook and winter steelhead.
- Maintain and restore riparian buffers, fence cattle out of streams, and minimize activities adjacent to streams that negatively impact anadromous habitat.

Habitats that need protection in the Lower Cowlitz Subbasin:

- Side channels within the mainstem Cowlitz provide critical and very limited spawning and rearing habitat for fall chinook and steelhead.

- Monahan Creek provides important coho, steelhead, and fall chinook habitat and was characterized by the TAG as having the best tributary habitat in the subbasin.
- The upper reaches of Olequa (above Winlock) and Delameter creeks provide important spawning and rearing habitat for steelhead, cutthroat, and coho.
- Upper Lacamas Creek may support a small population of chum salmon.

Toutle River Subbasin Habitat Limiting Factors

The 1980 eruption of Mount St. Helens severely impacted salmonid populations and their habitat. Yet, most stream systems are naturally recovering from the disturbance. The North Fork Toutle is one exception were recovery has lagged behind. TAG members attributed the slow recovery to the Sediment Retention Structure (SRS) that has altered natural recovery processes.

A number of habitat constraints still limit production within the subbasin including; limited floodplain, off-channel, and pool habitat, high width-to-depth ratios and poor riparian conditions that contribute to elevated stream temperatures, lack of instream cover and LWD, and unstable substrate conditions. Hydrologic immaturity and high road densities within the subbasin contribute to increased peak flows and additional channel instability. High road densities and numerous stream adjacent roads also contribute excessive amounts of fine sediment to stream channels. Access and water quality are two major limiting factors within the Silver Lake watershed.

Recommendations for addressing limiting factors in the Toutle River Subbasin:

- Removal or alteration of the SRS would facilitate natural recovery of the North Fork Toutle and downstream systems.
- Water quantity and water quality problems within the Silver Lake watershed need to be addressed.
- Reduce road densities and the miles of stream adjacent roads within the subbasin, and assess the condition of abandoned roads in the upper Toutle subbasin.
- Replant degraded riparian areas with native conifers.
- Look for opportunities to enhance or restore off-channel rearing habitat.

Habitats that need protection in the Toutle River Subbasin:

- TAG members felt that the South Fork and low-gradient reaches of its tributaries contained the most important habitat within the Toutle subbasin.
- Elk and Devils creeks are the most productive steelhead tributaries to the Green River, and Hoffstadt and Alder Creeks are the most productive in the North Fork Toutle watershed.
- Upper Wyant Creek provides important low-gradient coho habitat.

Mayfield/Tilton Subbasin Habitat Limiting Factors

Mayfield Dam forms a complete barrier to natural upstream migration and it inhibits downstream migration. Miles of formerly productive habitat were inundated by the reservoir and conditions now favor predators of juvenile salmonids.

Extensive timber harvest, high road densities, and numerous stream adjacent roads in the Tilton River watershed combine to decrease riparian function and water quality and to increase peak flows, inputs of fine sediments, and channel instability. TAG members felt that over-winter survival in the Tilton River watershed is below expectations due to elevated peak flows and a lack of pools and off-channel habitat for refuge. Juvenile rearing success is also reduced because of predation within the reservoir. With the high flows and lack of LWD, spawning gravels are also scoured from many areas of the Tilton watershed.

Recommendations for addressing limiting factors in the Mayfield/Tilton River Subbasin:

- Continue to monitor and increase the efficiency of reintroduction efforts above the dams. Downstream migration success is critical to these efforts
- Increase rearing success in this subbasin by upgrading road locations, crossings, and other floodplain constrictions, reduce road densities, maintain hydrologic maturity, and wherever possible restore and enhance floodplain connections and rearing habitat.
- Supplement LWD in appropriate stream channels to provide instream structure and cover, and enhance pool quality and spawning habitat.
- Establish functioning riparian corridors within the subbasin to increase water quality and recruitment potential for LWD.

Habitats that need protection in the Mayfield/Tilton River Subbasin:

- Side-channel habitat below the town of Morton provides some critical areas with refuge from high flows.
- Winston Creek supports a “healthy” run of resident cutthroat trout that need protection.
- The South Fork Tilton, the mainstem Tilton from Nineteen Creek (RM 22.9) to the falls (RM 25), and the West Fork Tilton provide some of the best habitat within the subbasin.
- Coon, Snow, and Trout creeks provide ideal summer-rearing areas for steelhead and resident trout.

Riffe Lake Subbasin Habitat Limiting Factors

Mossyrock Dam forms a complete barrier to both upstream and downstream passage. Downstream migrants (coho and chinook) are unable to navigate the 23-mile long lake. Until problems with downstream migration are addressed, reintroduction of anadromous salmonids is not planned or feasible within the subbasin.

Cispus River Subbasin Habitat Limiting Factors

Currently, the system of dams blocks all natural upstream passage and downstream migration. Downstream migrants are captured at the Cowlitz Falls Dam and transported below the dams. The reservoir, Lake Scanewa, has inundated the lower reaches of the Cispus River and Copper Canyon Creek, increasing predation and reducing key habitat for spawning, incubation, and fry colonization.

Past management practices on private and public lands, especially road construction and timber harvests have contributed to increased peak flows, excessive sediment delivery to streams, and bank instability, and reduced riparian function and instream LWD. A number of stream adjacent roads have also effectively channelized the river and isolated already limited off-channel rearing habitat. However, some areas within the subbasin have properly functioning habitat and new management practices should eventually address many of the remaining problems.

Recommendations for addressing limiting factors in the Cispus River Subbasin:

- Reintroduction efforts in the entire subbasin are dependent upon successful operation of the Cowlitz Falls Fish Collection Facility. It is critical to the recovery of anadromous fish that capture efficiency at the dam be monitored and improved over time.
- The USFS should continue to address road related problems that reduce floodplain connectivity and limit rearing habitat within the subbasin.
- Enhance existing instream habitat by supplementing LWD. Utilize LWD that collects at Mossyrock Dam for projects within the Cispus subbasin.
- Manage early- and mid-structural stands within riparian reserves to develop late-structural characteristics in the Cispus subbasin.
- Flow (cfs) thresholds for drawdowns should be reevaluated, and if possible increased, to assure that juveniles are not flushed over the dam into Riffe Lake.

Habitats that need protection in the Cispus River Subbasin:

- The North Fork Cispus provides some of the best functional habitat in the subbasin and protection of this system is the highest priority in the subbasin.
- Off-channel habitat within the mainstem Cispus between Iron Creek (RM 8.2) and the North Fork Cispus (RM 19.9) provides important rearing habitat for juveniles.
- Enhance the fair-quality habitats in the North Fork Cispus, Yellowjacket Creek, and Greenhorn Creek, (in order of priority).
- Maintain the high-quality habitats in Woods, Orr, and Iron creeks.

Upper Cowlitz Subbasin Habitat Limiting Factors

Currently, the system of dams blocks all natural upstream passage and downstream migration. Downstream migrants must be captured at the Cowlitz Falls Dam and transported below the dams. Trap efficiency varies with flow, and smolts are often flushed into Riffe Lake during drawdowns. Lake Scanewa inundated the once productive reaches of the upper Cowlitz increasing predation and reducing key habitat for spawning, incubation, and fry colonization.

Natural barriers to anadromous fish passage occur on many tributaries within a mile or two of the confluence with the upper Cowlitz River. The low-gradient habitat within these tributary channels provides a large proportion of the habitat within the subbasin. Channel alterations, combined with increased sediment inputs, have created low-flow passage problems and reduced habitat quality within these important reaches. LWD is generally lacking, resulting in limited pool habitat, cover, and habitat diversity in the mainstem and lower reaches of most tributaries. LWD recruitment potential is also low.

Recommendations for addressing limiting factors in the Upper Cowlitz Subbasin:

- Collection efficiency monitoring at the dam should continue, along with efforts to improve the efficiency of the collection equipment and process.
- Increase instream cover and habitat diversity in the upper reaches of Lake Skanewa to reduce the chance of flushing juveniles during drawdowns.
- Look for opportunities to enhance and restore rearing and spawning habitat within the low-gradient reaches of tributary habitat.
- Protect and restore riparian habitat along the mainstem Cowlitz and its tributaries, and supplement LWD in appropriate response reaches.

Habitats that need protection in the Upper Cowlitz Subbasin:

- The lower reaches of the Ohanapecosh and Clear Fork have pristine spawning and rearing habitat that provides especially critical spring chinook spawning habitat.
- Low-gradient tributary habitat provides critical spawning and rearing habitat for all species within the upper subbasin.
- Skate Creek has the best available habitat in the upper subbasin.

Data Gaps

The ability to determine what factors are limiting salmonid production, and to prioritize those factors within and between drainages, is limited by the current lack of specific habitat assessment data. Collecting this baseline data will be critical for developing effective recovery and restoration plans, for prioritizing future recovery efforts, and for monitoring the success of those efforts. The significant data gaps in WRIA 26 include:

- Watershed level processes such as hydrology, sediment transport and storage, nutrient cycling, and vegetation structure and composition;
- Recent and comprehensive data on the distribution and condition of stocks;
- Physical surveys of habitat conditions and fish usage within most stream systems;
- Comprehensive water quality data from all major subbasins;
- Data on the success of all phases of the reintroduction efforts in the Tilton River, Cispus, and upper Cowlitz subbasins.

The following chapters provide a detailed assessment of the habitat limiting factors within WRIA 26.

INTRODUCTION

Habitat Limiting Factors Background

The successful recovery of naturally spawning salmon populations depends upon directing actions simultaneously at harvest, hatcheries, habitat and hydro, the 4H's. The 1998 state legislative session produced a number of bills aimed at salmon recovery. Engrossed Substitute House Bill (ESHB) 2496 is a key piece of the 1998 Legislature's salmon recovery effort, with the focus directed at salmon habitat issues.
Engrossed Substitute House Bill (ESHB) 2496 in part:

- directs the Conservation Commission in consultation with local government and the tribes to invite private, federal, state, tribal and local government personnel with appropriate expertise to act as a technical advisory group;
- directs the technical advisory group to identify limiting factors for salmonids to respond to the limiting factors relating to habitat pursuant to section 8 sub 2 of this act;
- defines limiting factors as "conditions that limit the ability of habitat to fully sustain populations of salmon."
- defines salmon as all members of the family salmonidae, which are capable of self-sustaining, natural production.

The overall goal of the Conservation Commission's limiting factors project is to identify habitat factors limiting production of salmonids in the state. At this time, the report identifies habitat limiting factors pertaining to salmon, steelhead trout and includes bull trout when they share the same waters with salmon and steelhead. Later, we will add bull trout-only waters, as well as specific factors that relate to cutthroat.

It is important to note that the responsibilities given to the Conservation Commission in ESHB 2496 do not constitute a full limiting factors analysis. The hatchery, hydro and harvest segments of identifying limiting factors are being dealt with in other forums.

The Role of Habitat in a Healthy Population of Natural Spawning Salmon

During the last 10,000 years, Washington State anadromous salmonid populations have evolved in their specific habitats (Miller 1965). Water chemistry, flow, and the physical stream components unique to each stream have helped shape the characteristics of every salmon population. These unique physical attributes have resulted in a wide variety of distinct salmon stocks for each salmon species throughout the State. Within a given species, stocks are population units that do not extensively interbreed because returning adults rely on a stream's unique chemical and physical characteristics to guide them to their natal grounds to spawn. This maintains the separation of stocks during reproduction, thus preserving the distinctiveness of each stock.

Throughout the salmon's life cycle, the dependence between the stream and a stock continues. Adults spawn in areas near their own origin because survival favors those that do. The timing of juveniles leaving the river and entering the estuary is tied to high natural river flows. It has been theorized that the faster speed during out-migration reduces predation on the young salmon and perhaps is coincident to favorable feeding conditions in the estuary (Wetherall 1971). These are a few examples that illustrate how a salmon stock and its environment are intertwined throughout the entire life cycle.

Salmon habitat includes the physical, chemical and biological components of the environment that support salmon. Within freshwater and estuarine environments, these components include water quality, water quantity or flows, stream and river physical features, riparian zones, upland terrestrial conditions, and ecosystem interactions as they pertain to habitat. However, these components closely intertwine. Low stream flows can alter water quality by increasing temperatures and decreasing the amount of available dissolved oxygen, while concentrating toxic materials. Water quality can impact stream conditions through heavy sediment loads, which result in a corresponding increase in channel instability and decrease in spawning success. The riparian zone interacts with the stream environment, providing nutrients and a food web base, woody debris for habitat and flow control (stream features), filtering runoff prior to surface water entry (water quality), and providing shade to aid in water temperature control.

Salmon habitat includes clean, cool, well-oxygenated water flowing at a normal (natural) rate for all stages of freshwater life. In addition, salmon survival depends upon specific habitat needs for egg incubation, juvenile rearing, migration of juveniles to saltwater, estuary rearing, ocean rearing, adult migration to spawning areas, and spawning. These specific needs can vary by species and even by stock.

When adults return to spawn, they not only need adequate flows and water quality, but also unimpeded passage to their natal grounds. They need deep pools with vegetative cover and instream structures such as root wads for resting and shelter from predators. Successful spawning and incubation depend on sufficient gravel of the right size for that particular population, in addition to the constant need of adequate flows and water quality, all in unison at the necessary location. Also, delayed upstream migration can be critical. After entering freshwater, most salmon have a limited time to migrate and spawn, in some cases, as little as 2-3 weeks. Delays can results in pre-spawning mortality, or spawning in a sub-optimum location.

After spawning, the eggs need stable gravel that is not choked with sediment. River channel stability is vital at this life history stage. Floods have their greatest impact to salmon populations during incubation, and flood impacts are worsened by human activities. In a natural river system, the upland areas are forested, and the trees and their roots store precipitation, which slows the rate of storm water into the stream. The natural, healthy river is sinuous and contains large pieces of wood contributed by an intact, mature riparian zone. Both slow the speed of water downstream. Natural systems have floodplains that are connected directly to the river at many points, allowing wetlands to store flood water and later discharge this storage back to the river during lower flows. In a healthy river, erosion or sediment input is great enough to provide new gravel for spawning and incubation, but does not overwhelm the system, raising the riverbed and increasing channel instability. A stable incubation environment is essential for salmon, but is a complex function of nearly all habitat components contained within that river ecosystem.

Once the young fry emerge from the gravel nests, certain species such as chum, pink, and some chinook salmon quickly migrate downstream to the estuary. Other species, such as coho, steelhead, bull trout, and chinook, will search for suitable rearing habitat within the side sloughs and channels, tributaries, and spring-fed "seep" areas, as well as the outer edges of the stream. These quiet-water side margin and off channel slough areas are vital for early juvenile habitat. The presence of woody debris and overhead cover aid in food and nutrient inputs as well as provide protection from predators. For most of these species, juveniles use this type of habitat in the spring. Most sockeye populations migrate from their gravel nests quickly to larger lake environments where they have unique habitat requirements. These include water quality sufficient to produce the necessary complex food web to support one to three years of salmon growth in that lake habitat prior to outmigration to the estuary.

As growth continues, the juvenile salmon (parr) move away from the quiet shallow areas to deeper, faster areas of the stream. These include coho, steelhead, bull trout, and certain chinook. For some of these species, this movement is coincident with the summer low flows. Low flows constrain salmon production for stocks that rear within the stream. In non-glacial streams, summer flows are maintained by precipitation, connectivity to wetland discharges, and groundwater inputs. Reductions in these inputs will reduce that amount of habitat; hence the number of salmon dependent on adequate summer flows.

In the fall, juvenile salmon that remain in freshwater begin to move out of the mainstems, and again, off-channel habitat becomes important. During the winter, coho, steelhead, bull trout, and remaining chinook parr require habitat to sustain their growth and protect them from predators and winter flows. Wetlands, stream habitat protected from the effects of high flows, and pools with overhead are important habitat components during this time.

Except for bull trout and resident steelhead, juvenile parr convert to smolts as they migrate downstream towards the estuary. Again, flows are critical, and food and shelter are necessary. The natural flow regime in each river is unique, and has shaped the population’s characteristics through adaptation over the last 10,000 years. Because of the close inter-relationship between a salmon stock and its stream, survival of the stock depends heavily on natural flow patterns.

The estuary provides an ideal area for rapid growth, and some salmon species are heavily dependent on estuaries, particularly chinook, chum, and to a lesser extent, pink salmon. Estuaries contain new food sources to support the rapid growth of salmon smolts, but adequate natural habitat must exist to support the detritus-based food web, such as eelgrass beds, mudflats, and salt marshes. Also, the processes that contribute nutrients and woody debris to these environments must be maintained to provide cover from predators and to sustain the food web. Common disruptions to these habitats include dikes, bulkheads, dredging and filling activities, pollution, and alteration of downstream components such as lack of woody debris and sediment transport.

All salmonid species need adequate flow and water quality, spawning riffles and pools, a functional riparian zone, and upland conditions that favor stability, but some of these specific needs vary by species, such as preferred spawning areas and gravel. Although some overlap occurs, different salmon species within a river are often staggered in their use of a particular type of habitat. Some are staggered in time, and others are separated by distance.

Chum and pink salmon use the streams the least amount of time. Washington adult pink salmon typically begin to enter the rivers in August and spawn in September and October, although Dungeness summer pinks enter and spawn a month earlier (WDFW and WWTIT 1994). During these times, low flows and associated high temperatures and low dissolved oxygen can be problems. Other disrupted habitat components, such as less frequent and shallow pools from sediment inputs and lack of canopy from an altered riparian zone or widened river channel, can worsen these flow and water quality problems because there are fewer refuges for the adults to hold prior to spawning.
Pink salmon fry emerge from their gravel nests around March and migrate downstream to the estuary within a month. After a limited rearing time in the estuary, pink salmon migrate to the ocean for a little over a year, until the next spawning cycle. Most pink salmon stocks in Washington return to the rivers only in odd years. The exception is the Snohomish Basin, which supports both even- and odd-year pink salmon stocks.

In Washington, adult chum salmon (3-5 years old) have three major run types. Summer chum adults enter the rivers in August and September, and spawn in September and October. Fall chum adults enter the rivers in late October through November, and spawn in November and December. Winter chum adults enter from December through January and spawn from January through February. Chum salmon fry emerge from the nests in March and April, and quickly outmigrate to the estuary for rearing. In the estuary, juvenile chum follow prey availability. In Hood Canal, juveniles that arrive in the estuary in February and March migrate rapidly offshore. This migration rate decreases in May and June as levels of zooplankton increase. Later as the food supply dwindles, chum move offshore and switch diets (Simenstad and Salo 1982). Both chum and pink salmon have similar habitat needs such as unimpeded access to spawning habitat, a stable incubation environment, favorable downstream migration conditions (adequate flows in the spring), and because they rely heavily on the estuary for growth, good estuary habitat is essential.

Chinook salmon have three major run types in Washington State. Spring chinook are generally in their natal rivers throughout the calendar year. Adults begin river entry as early as February in the Chehalis, but in Puget Sound, entry doesn't begin until April or May. Spring chinook spawn from July through September and typically spawn in the headwater areas where higher gradient habitat exists. Incubation continues throughout the autumn and winter, and generally requires more time for the eggs to develop into fry because of the colder temperatures in the headwater areas. Fry begin to leave the gravel nests in February through early March. After a short rearing period in the shallow side margins and sloughs, all Puget Sound and coastal spring chinook stocks have juveniles that begin to leave the rivers to the estuary throughout spring and into summer (August).

Within a given Puget Sound stock, it is not uncommon for other chinook juveniles to remain in the river for another year before leaving as yearlings, so that a wide variety of outmigration strategies are used by these stocks. The juveniles of spring chinook salmon stocks in the Columbia Basin exhibit some distinct juvenile life history characteristics. Generally, these stocks remain in the basin for a full year. However, some stocks migrate downstream from their natal tributaries in the fall and early winter into larger rivers, including the Columbia River, where they are believed to over-winter prior to outmigration the next spring as yearling smolts.

Adult summer chinook begin river entry as early as June in the Columbia, but not until August in Puget Sound. They generally spawn in September and/or October. Fall chinook stocks range in spawn timing from late September through December. All Washington summer and fall chinook stocks have juveniles that incubate in the gravel until January through early March, and outmigration downstream to the estuaries occurs over a broad time period (January through August). A few of these stocks have a component of juveniles that remain in freshwater for a full year after emerging from the gravel nests.

While some emerging chinook salmon fry outmigrate quickly, most inhabit the shallow side margins and side sloughs for up to two months. Then, some gradually move into the faster water areas of the stream to rear, while others outmigrate to the estuary. Most summer and fall chinook outmigrate within their first year of life, but a few stocks (Snohomish summer chinook, Snohomish fall chinook, upper Columbia summer chinook) have juveniles that remain in the river for an additional year, similar to many spring chinook (Marshall et al. 1995). However, those in the upper Columbia, have scale patterns that suggest that they rear in a reservoir-like environment (mainstem Columbia upstream from a dam) rather than in their natal streams and it is unknown whether this is a result of dam influence or whether it is a natural pattern.

The onset of coho salmon spawning is tied to the first significant fall freshet. They typically enter freshwater from September to early December, but have been observed as early as late July and as late as mid-January (WDF et al. 1993). They often mill near the river mouths or in lower river pools until freshets occur. Spawning usually occurs between November and early February, but is sometimes as early as mid-October and can extend into March. Spawning typically occurs in tributaries and sedimentation in these tributaries can be a problem, suffocating eggs. As chinook salmon fry exit the shallow low-velocity rearing areas, coho fry enter the same areas for the same purpose. As they grow, juveniles move into faster water and disperse into tributaries and areas which adults cannot access (Neave 1949). Pool habitat is important not only for returning adults, but for all stages of juvenile development. Preferred pool habitat includes deep pools with riparian cover and woody debris.

All coho juveniles remain in the river for a full year after leaving the gravel nests, but during the summer after early rearing, low flows can lead to problems such as a physical reduction of available habitat, increased stranding, decreased dissolved oxygen, increased temperature, and increased predation. Juvenile coho are highly territorial and can occupy the same area for a long period of time (Hoar 1958). The abundance of coho can be limited by the number of suitable territories available (Larkin 1977). Streams with more structure (logs, undercut banks, etc.) support more coho (Scrivener and Andersen 1982), not only because they provide more territories (useable habitat), but they also provide more food and cover. There is a positive correlation between their primary diet of insect material in stomachs and the extent the stream was overgrown with vegetation (Chapman 1965). In addition, the leaf litter in the fall contributes to aquatic insect production (Meehan et al. 1977).

In the autumn as the temperatures decrease, juvenile coho move into deeper pools, hide under logs, tree roots, and undercut banks (Hartman 1965). The fall freshets redistribute them (Scarlett and Cederholm 1984), and over-wintering generally occurs in available side channels, spring-fed ponds, and other off-channel sites to avoid winter floods (Peterson 1980). The lack of side channels and small tributaries may limit coho survival (Cederholm and Scarlett 1981). As coho juveniles grow into yearlings, they become more predatory on other salmonids. Coho begin to leave the river a full year after emerging from their gravel nests with the peak outmigration occurring in early May. Coho use estuaries primarily for interim food while they adjust physiologically to saltwater.

Sockeye salmon have a wide variety of life history patterns, including landlocked populations of kokanee which never enter saltwater. Of the populations that migrate to sea, adult freshwater entry varies from spring for the Quinault stock, summer for Ozette, to summer for Columbia River stocks, and summer and fall for Puget Sound stocks. Spawning ranges from September through February, depending on the stock.
After fry emerge from the gravel, most migrate to a lake for rearing, although some types of fry migrate to the sea. Lake rearing ranges from 1-3 years. In the spring after lake rearing is completed, juveniles enter the ocean where more growth occurs prior to adult return for spawning.

Coastal cutthroat have four life-history forms including anadromous (coastal), fluvial (riverine), adfluvial (lacustrine), and resident (headwaters). Depending on specific watershed characteristics, all forms can occur within the same watershed. Coastal cutthroat exhibit the broadest range of occupied habitats, migratory behavior, age at first spawning, and frequency of repeat spawning of any salmonids (Johnson 1981, Northcote 1997 as cited in WDFW 2000).

Anadromous coastal cutthroat typically spawn in small streams. In Washington, most anadromous coastal cutthroat spawn from January through April, with the peak of spawning in February. Spawning occurs in riffles where the water depth is about 15 to 45 cm, in areas of low gradient and low flow (Johnson 1981, Trotter 1989 as cited in WDFW 2000). Adults surviving after spawning tend to return to salt water in late March and early April (Trotter 1989 as cited in WDFW 2000) Survival after spawning and the number of times adults return to spawn during its lifetime is variable, but individuals may return to spawn as often as 6 times (Johnson et. al. 1999).

Eggs hatch within six to seven weeks, and alevins remain in gravel for about two weeks after hatching (Trotter 1989 as cited in WDFW 2000). Fry emerge from spawning gravels from March through June (Johnson et. al. 1999). Newly emerged fry move quickly to low-velocity water at stream margins and backwaters and remain there through the summer to feed (Trotter 1989 as cited in WDFW 2000). Most juveniles remain in freshwater for two to four years before smolting and migrating to salt water, though the range extends from one to six years (WDFW 2000). Emigration occurs in spring.

Upon reaching salt water most coastal cutthroat are thought to remain fairly close to shore or within estuaries. After feeding in salt water for several months most coastal cutthroat return to freshwater to overwinter and spawn. Fish returning to larger river systems with higher summer flows tend to enter from August through October, while those returning to smaller streams with lower summer flows tend to return from November through March (WDFW 2000).

WATERSHED CONDITIONS

Location

Water Resource Inventory Area (WRIA) 26 is located in Southwest Washington within Lewis, Cowlitz, Skamania, Pierce, and Yakima counties (see Figure 1: WRIA 26 Location Map). River systems within the WRIA include the Cowlitz River and its tributaries. The Cowlitz River drains an area of approximately 2,480 square miles of the western slopes of the Cascade Range from Mount Rainier south to Mount Adams and Mount St. Helens. Formed by the confluence of the Clear Fork and the Ohanapecosh River, the main Cowlitz flows generally southwest for about 133 miles to join the Columbia River at river mile (RM) 68 approximately 3.5 miles southeast of Longview, Washington (WDF 1951).

Watershed Description

The headwater areas are mountainous and heavily timbered, and the upper tributaries flow through deep, narrow canyons with steep gradients. A short distance below the junction of the Muddy Fork and the Ohanapecosh River the valley floor opens out to a width of about one-half mile. At Randle (RM 103) the valley floor widens to a mile or more (WDF 1951). Just below Lower Cowlitz Falls (RM 88.5), Cowlitz Falls Dam was constructed in 1994, flooding 610 acres and extending 11 miles upstream (see Table 1). At RM 66, the river enters Youngs Canyon. Historically, the river flowed through a boxed canyon for a 14-mile reach from Youngs Canyon to the foot of Mayfield Canyon at RM 52 (WDF 1951). The 606-foot-high Mossyrock Dam was built at the entrance to Youngs Canyon in 1968 creating Riffe Lake that now impounds water upriver for 23.8 miles (see Table 1). Riffe is operated as an annual storage reservoir for flood control and hydropower with large fluctuations in water levels during the year (Gaia Northwest, Inc. 1993). Due to the height of the dam, length of the reservoir, depth of the penstock intakes, and location of Mossyrock Dam upstream of Mayfield Dam, fish facilities were not incorporated into the dam (Gaia Northwest, Inc. 1993).

Mayfield Dam was built at the foot of Mayfield Canyon (RM 52) creating Mayfield Lake in 1962. Mayfield Lake extends 13.5 miles upstream of the dam. Upstream passage facilities were utilized until 1969 until it was determined that downstream migrants could not be passed around Mossyrock Dam (Gaia Northwest, Inc. 1993). In 1969, the Departments of Fisheries and of Wildlife began collecting adults at the salmon hatchery barrier dam, 1.5 miles downstream of Mayfield Dam. Since 1969, all adult salmon and steelhead passed upstream of Mayfield Dam have been hauled via trucks, and no natural passage remains (Gaia Northwest, Inc. 1993).

Downstream of the Barrier Dam at RM 49.5 the stream flows generally southward and the valley widens to approximately three miles (WDF 1951). Below the confluence with the Toutle River (RM 20) the Cowlitz River channel has been almost completely armored and diked, and most of the floodplain has been filled with deposits from the eruption of Mount St. Helens.

Table 1: Comparison of Reservoir Characteristics

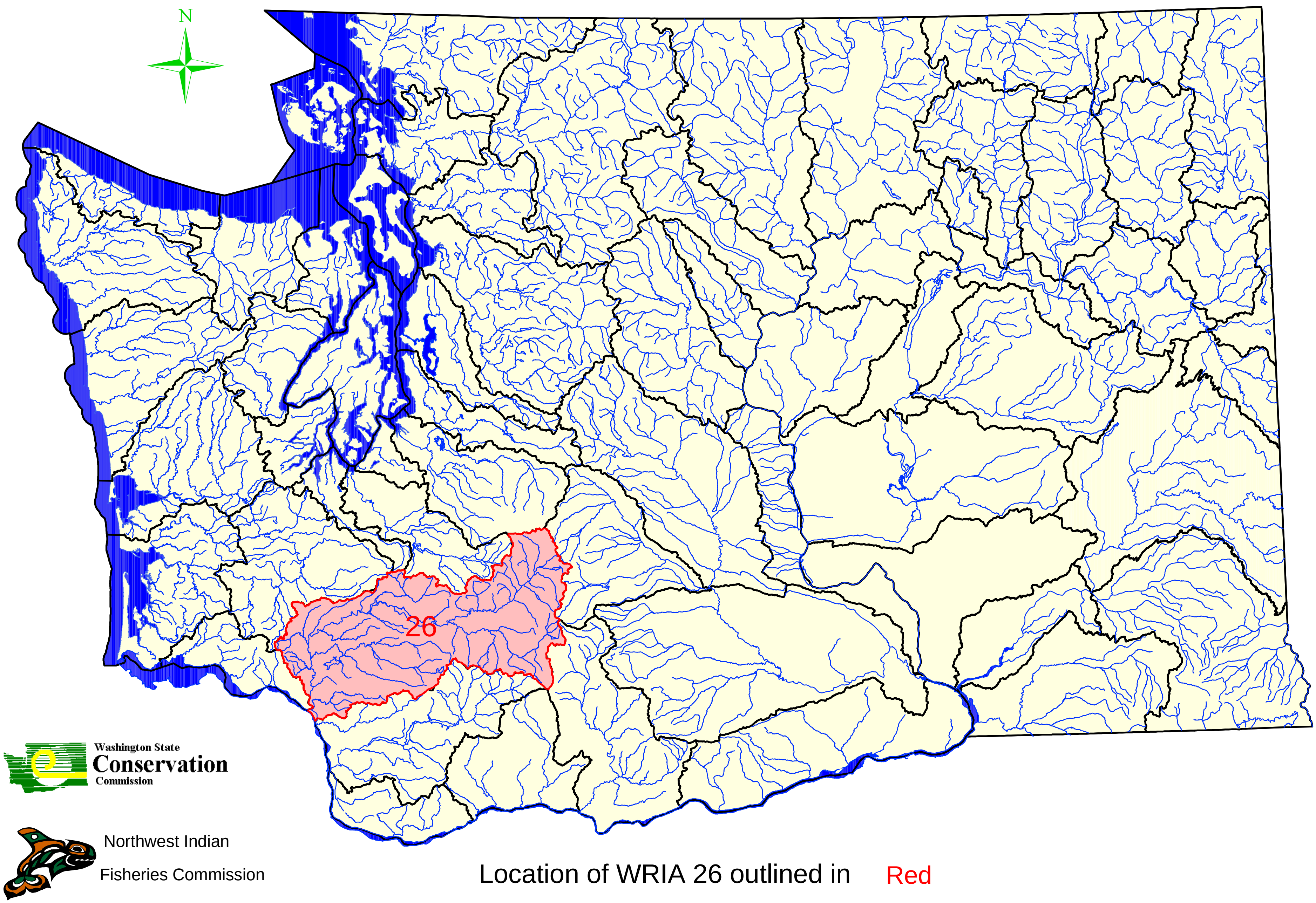
Parameter	**Cowlitz Falls**	**Riffe Lake**	**Mayfield Lake**
River Mile	88.5	65.5	52
Average annual Flow (CFS)	4,600	5,057	6,345
Storage (acre feet)	11,000	1,298,002	133,720
Area (acres)	610	11,335	2,200
Average Retention Time (days)	1	168	19
Reservoir Length (miles)	11	23.8	13.5
Reservoir Width (miles)	--	2	0.75
Normal Draw-down (feet)	2	33	1
Intake Level (ft below surface)	60	210	36
Inflow to Volume Ratio	332	2.2	34.3

Adapted from Gaia Northwest, Inc 1993

For the purposes of developing this Limiting Factors Analysis, WRIA 26 was divided into 7 subbasins (see Map 4 in Appendix A):

1. Coweeman River subbasin: which includes the mainstem Cowlitz River below RM 20, the Coweeman River watershed and it's tributaries, Ostrander Creek, and other smaller tributaries that enter the Cowlitz River on the left bank (facing downstream).
2. Lower Cowlitz Subbasin: which includes the mainstem Cowlitz River and its tributaries from the Toutle River confluence (RM 20) to Mayfield Dam (RM 52) and right bank tributaries west of the mainstem Cowlitz between Longview and the Toutle River confluence. Larger tributaries in this subbasin include Arkansas, Olequa, Lacamas, Salmon, and Mill creeks.
3. Toutle River Subbasin: which includes the Toutle River, Green River, North and South Forks of the Toutle, and all of the remaining Toutle River tributaries.
4. Mayfield/Tilton Subbasin: which includes Mayfield Lake, the Tilton River system, and Winston Creek watershed. Some of the larger tributaries to the Tilton River are the North, South, East, and West Forks of the Tilton, Lake Creek, Nineteen Creek, and Connelly Creek.
5. Riffe Lake Subbasin: which includes Riffe Lake, Rainey Creek, and various other smaller tributaries.
6. Cispus River Subbasin: which includes the Cispus River watershed and it's major tributaries including the North Fork Cispus and Yellowjacket Creek.
7. Upper Cowlitz River Subbasin: which includes the Cowlitz River mainstem above RM 88.5 (Cowlitz Falls Dam) and its major tributaries including, Kiona Creek, Skate Creek, and the Ohanapecosh, Clear Fork, and Muddy Fork Rivers.

Map 1 Location of WRIA 26



Location of WRIA 26 outlined in Red

Topography

The Cowlitz River flows generally westward from Mount Rainier, the highest mountain in Washington State at 14,410 feet, to the Columbia River. The eastern part of the Cowlitz River valley is located in the Cascade physiographic province and is characterized by a deeply cut trough and flat bottomlands, terraces, and broad plains. To the north and south of the valley, the uplands have rugged mountainous topography, modified by glacial activity and drained by rivers that trend generally westward (Harza 1999c). Landscape characteristics include, long steep slopes and relatively straight, parallel drainage ways. The western portion of the Cowlitz River valley lies within the northern end of the Puget-Willamette Lowlands physiographic province, and has moderate relief with a broad floodplain; elevations seldom exceed 500 feet (WDW 1990).

Geology

The Cowlitz River originates in the volcanic rocks of the Southern Cascade Mountains. Three volcanic peaks are located in the headwaters of the basin. The river flows west through a valley heavily influenced by alpine glaciers, then turns south and flows between the Cascades and the Willapa Hills to the Columbia River (Harza 1999c).

The upper Cowlitz basin is located in Washington's southern Cascades, which are made up primarily of andesite and basalt flows and associated breccias and tuffs. Areas adjacent to volcanic peaks are generally mantled with pumice deposits (WDW 1990). Soils in alluvial deposits along the major west-flowing streams are generally coarse textured soils (Franklin and Dyrness 1973 as cited in WDW 1990). The lower half of the basin is generally comprised of Eocene basalt flows and flow breccia. Haplohumults (reddish brown lateritic soils) are the most common under forest vegetation; soils under grasslands are classed as Argixerolls (prairie soils) (WDW 1990).

Potentially severe erosion would occur on over 83 percent of the land in WRIA 26 if vegetative cover were removed. Over 81 percent of the land with severe to very severe erosion hazard is in commercial forest (USSCS 1974). The greatest erosion problems are from ground disturbance from road building and other activities associated with logging (USSCS 1974).

During the Pleistocene (3 m.y.a to 8,000 years ago) several alpine glaciers moved down the Cowlitz River valley depositing till and outwash (glacial river sand and gravel deposits). These glaciers, 1000 feet thick or more, cut down into the former river channel and underlying bedrock (Coombs 1989 as cited in Harza 1999c). At least six alpine glacial advances have been documented. Glacial outwash sands and gravels form terraces in the vicinity of the Cowlitz River and were deposited by streams from the melting alpine glaciers located up the valley. Silt-loam loess, representing windblown glacial silt, blankets large areas of the basin (Crandall and Miller 1974 as cited in Harza 1999c). The thickness of the loess varies from a few feet to 20 feet.

Following deposition of the youngest glacial deposits, approximately 13,000 to 25,000 years ago, the Cowlitz River eroded and reworked the glacial deposits. The resulting alluvial deposits range from coarse boulders to cobbly gravel to fine sand and silty sand. Thick alluvium is generally confined to the area of the immediate Cowlitz River flood plain (Harza 1999c).

Climate

Climate in WRIA 26 is typical of the West Coast marine type. Winters are mild, wet and cloudy, while summers are warm and dry. Snow and freezing temperatures are uncommon in the basin, but occur in the winter especially at higher elevations. Annual precipitation varies from 45 inches near Kelso to over 150 inches on Mount Rainier, Adams, and St. Helens. Most precipitation occurs between October 1 and March 31 as rain (WDW 1990). A summary of precipitation data for Mayfield Dam and Paradise, Washington is presented in Table 2.

Table 2: Average monthly precipitation in inches recorded at Mayfield Dam and at Paradise on Rainier.

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average for Years 1981-1994
Mayfield Dam	6.6	5.7	5.8	5.2	3.4	3.1	1.3	1.1	2.1	4.3	8.7	6.3	53.9
Paradise	15	12.2	10.4	10.2	6.2	4.1	2.1	1.6	4.2	9.22	20.1	14.3	108.1

Adapted from Harza 1999c

Vegetation Structure and Composition

The forest series or zones in the Cowlitz watershed are typical of those found in the southern Cascades of Washington State. These forest zones are based on the climax tree species of the four major plant communities within the basin (western hemlock, Pacific silver fir, mountain hemlock, and subalpine fir). Above 3,500 feet, forests are generally Pacific silver fir with Douglas fir, western hemlock, mountain hemlock, and lodgepole pine as common associates. Understory is primarily huckleberry, fool's huckleberry, and salal. Below 3,500 feet, climax species are western hemlock, Douglas fir, and western red cedar. Understory species include vine maple, huckleberry, salal, sword fern, and devil's club. Hardwood species (alder, cottonwood, maple, and willow) are concentrated in riparian corridors along larger streams and rivers (WDW 1990).

Historically, fire was the strongest natural disturbance influencing vegetation structure and composition within these different plant communities (USFS 1997a). However, the eruption of Mount St. Helens has shown the potential influence that volcanism can also exert on vegetation composition and structure within the watershed. Logging, and in areas grazing, have also had substantial impacts on vegetation structure and composition and riparian areas throughout WRIA 26 (WDW 1990).

The Washington Department of Natural Resources derived vegetation cover for 26 WRIAs in Western Washington, including WRIA 26, using 1988 Landsat 5 TM data (PMR 1993) and updated with 1991 and 1993 TM data (see Lunetta et. al. 1997 for additional details). Forest cover was broadly categorized into four classes based on forest type and age class (see Table 3). The non-forest land cover and most surface water features were then overlaid on the forest-cover classification to discriminate non-forest lands, such as agriculture and urban areas from forest lands (PMR 1993).

Table 3: Land Cover Categories Derived from Landsat 5 TM data (PMR 1993 and WDNR 1994).

Land Cover Category	Description
Class 1: Late Seral Stage	Coniferous crown cover >70%. More than 10% crown cover in trees ≥21 inches in diameter breast height (dbh)
Class 2: Mid-Seral Stage	Coniferous crown cover >70%. Less than 10% crown cover in trees ≥21 inches dbh
Class 3: Early Seral Stage	Coniferous crown cover ≥10% and 70%. Less than 75% of total crown cover in hardwood tree/scrub cover.
Class 4: Other Land in Forested Areas	Less than 10% coniferous crown cover (can contain hardwood tree/scrub cover; cleared forest land; etc.
Class 5: Surface Water	Lakes, large rivers, and other water bodies
Class 15: Non-Forest Lands	Urban, agriculture, rangeland, barren, and glaciers

Adapted from Lunetta et. al. 1997.

Table 4 contains the both the number of acres in each land cover category and the percentage of the total area in each category. Late seral stage vegetation still covers a fairly large percentage of the Cowlitz River basin. USFS (1997a) estimates that 28% of the vegetation cover in the upper Cowlitz River watershed and 19% in the middle Cowlitz watershed is in “large tree” (similar characteristics to late seral stage).

Table 4: WRIA 26 Land Cover Data

WRIA 26	Late Seral	Mid Seral	Early Seral	Other Lands	Water	Non Forest
Acres	336,112	289,972	108,750	688,856	23,260	147,489
Percent	21	18	7	43	2	9

Adapted from Lunetta et. al. 1997.

Disturbance Regime

Historically, fire has also been the most significant overall disturbance mechanism in the Cowlitz watershed (USFS 1997a and 1997b). Large fires within a watershed will tend to increase siltation through erosion, alter the timing and quantity of high and low flows, influence stream temperatures, and increase the short-term LWD supply to streams and decrease the long-term supply (USFS 1995). In general, riparian areas tend to have microclimatic effects which somewhat protect them from many wildfire events so that late-seral stands are more prevalent there. This effect is more pronounced in steeper drainages.

Historically, fires in the Cowlitz basin were low in frequency, but high in severity, and had the potential to be quite large. For example, six fires of 1,000 acres or larger burned in the Middle and Upper Cowlitz watershed analysis areas between approximately mid-to-late 1800 to 1920. The largest fire burned approximately 27,000 acres (USFS 1997a). Fire suppression activity since the 1930's has significantly reduced the potential natural wildfire effects for this watershed (USFS 1997a).

Volcanic activity can have significant influence on aquatic habitats as evidenced by the recent eruption of Mount St. Helens. Mount St. Helens has deposited ash and pumice across portions of the Cowlitz watershed at least twice over the last 4,000 years; it erupted a cluster of times during the Smith Creek Eruptive Stage (3,900 to 3,400 years ago) and again during the 1980 eruptive phase (USFS 1997b). Mount St. Helens has erupted about once every century for the last 500 years, and is expected to follow a similar pattern in future centuries (USFS 1997b). Mount Rainier is another active volcano in the Cowlitz basin that is potentially the most dangerous volcano in the Cascade Range. Many debris flows and their distal phases have inundated areas far from the volcano during postglacial time (Scott et. al. 1995 in USFS 1997b). According to recent hazard maps of the area (Scott and Valance 1995 in USFS 1997b), most of the upper Cowlitz River valley (floodplain) could be inundated by a mudflow, with or without an associated volcanic eruption.

The 1980 eruption of Mount St. Helens devastated fisheries resources in the North and South Fork Toutle River watersheds (WDW 1990; Lucas 1986; Jones and Salo 1986; Lislie et al. 1982; Collins and Dunne 1981). Tributaries in the upper North Fork Toutle watershed were completely destroyed as massive landslides and debris-flows traveled 21.7 km (13.5 miles) down the North Fork (Jones and Salo 1986). Deposition of debris flows buried 59 km^2 (23 square miles) of terrain to an average depth of 46 meters (150 feet), including more than 43.4 km (27 miles) of anadromous stream habitat (Jones and Salo 1986). Many stream systems that were not directly affected by the debris flows were still blanketed with substantial amounts of ashfall and had most of the vegetation in the watershed blown down by the eruption (Lucas 1986).

Over 74 million cubic yards of material had to be removed from the Cowlitz River within the first year after the 1980 eruption to maintain flood capacity (Cowlitz County 1983). Floodplain and wetland habitat along portions of the lower Cowlitz and Toutle Rivers was filled with the dredge spoils. Stream systems are recovering slowly from the effects of the eruption; however, elevated sediment loads, channel widening, lack of large woody debris and riparian cover all remain problems today.

Hydrology

Primarily, Cowlitz River runoff results from rainfall. During the late spring, however, snowmelt from the headwaters area contributes appreciably to the stream flow (WDF 1951). In the upper basin, river flows are influenced by spring snowmelt and dry summer conditions. A few major tributaries drain glaciers on Cascade peaks and contribute glacial meltwater during the summer months. Stream gages near Kosmos RM 88.7 show a few peaks in May and June triggered by rapid snowmelt (see Figure 2). However, the majority of peak flows occur between November and February, indicating that winter rain or rain-on-snow events trigger most floods in the basin (Harza 1999c). Flow in small tributary streams in the lower basin is controlled more by rainfall than snowmelt, and peak flows are usually triggered by fall and winter rainstorms (Harza 1999c). Figure 2 from Harza (1999c) illustrates the mean daily flow by month at various locations along the river.

Three major hydroelectric projects on the mainstem Cowlitz significantly affect flow regimes in WRIA 26. Of the three dams, the Cowlitz Falls Dam is located farthest upstream just upstream of Riffe Lake and is the most recently constructed. The Cowlitz Falls Dam created Lake Scanewa, a small reservoir approximately 11 miles long. The dam and reservoir are operated in "run-of-the-river mode" with some large daily fluctuations for power production purposes (Harza 1999c). Riffe Lake, behind Mossyrock Dam, acts as a huge storage facility to both control flood flows and to hold water for future power generation. Flows out of Mayfield Dam are controlled by managing the storage in Riffe Lake (Harza 1999c). Riffe Lake is drawn down in the fall to provide flood storage for winter flood flows. Mayfield Lake, on the other hand, is a much smaller reservoir and is generally not drawn down and does not provide significant flood storage (Harza 1999c). When inflow to Mayfield Lake from the Tilton River and Winston Creek is high, generation at Mossyrock powerhouse might be shut down entirely to minimize flows to the lower river.

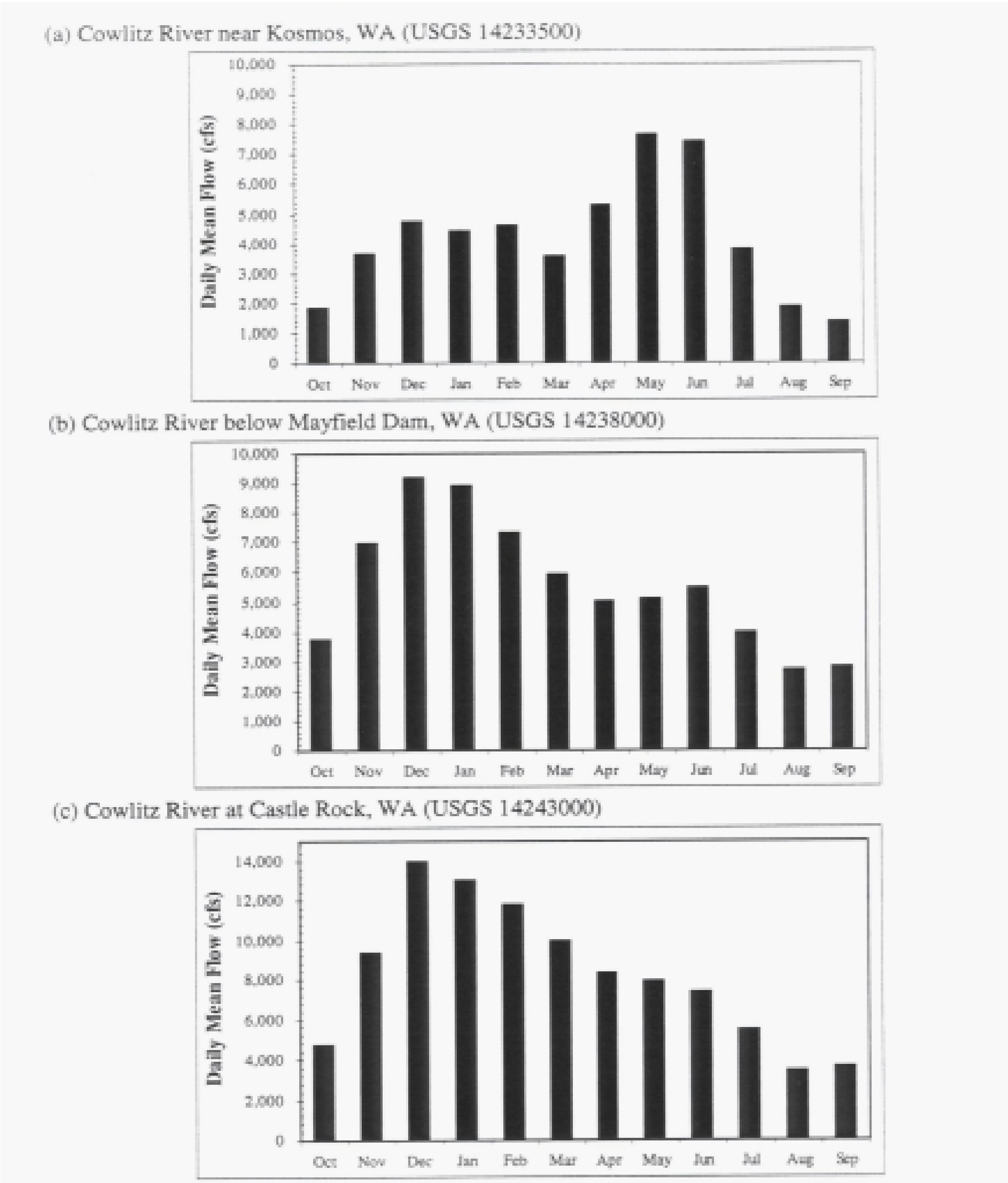
Computed flow frequencies for gages along the Cowlitz River are shown in Table 5. The analysis of flood frequencies is based on the highest (peak) instantaneous flow that occurs at a stream gage each year for the analysis period (1969-1997). The results of the analysis are described as the probability of a peak flow occurring in a given year, or a typical return period for a given peak flow (Harza 1999c). Under current conditions, the effects of the operation of the dams can be seen by comparing the peak flows for certain return periods at the Kosmos gage (upstream of the dams) with the gage below Mayfield Dam. Near Castle Rock, the contribution of flood flows from the Toutle River and other lower Cowlitz River tributaries again increases peak flow magnitude in the lower river to levels greater than experienced above the dams.

Table 5: Computed flood frequency under current conditions on the Cowlitz River (peak flows in cfs, based on 1969-1997 data)

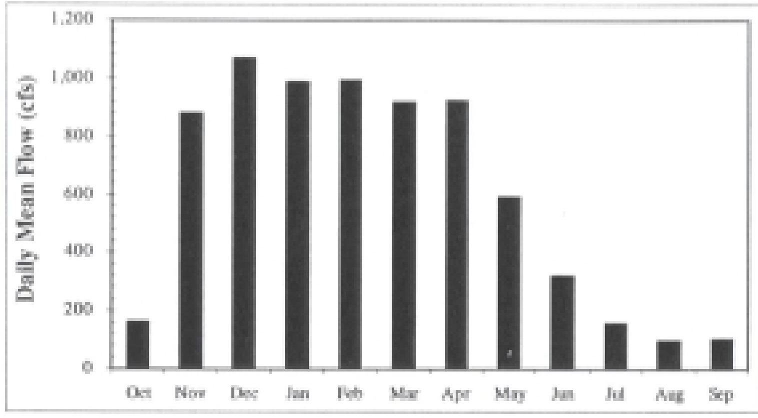
Return Period (years)	Cowlitz river near Kosmos (RM 88.7)	Cowlitz River below Mayfield Dam (RM 50.6)	Cowlitz River near Castle Rock (RM 17.3)
2	32,700 cfs	23,400 cfs	50,000 cfs
5	53,600 cfs	35,400 cfs	78,300 cfs
10	70,200 cfs	44,600 cfs	97,500 cfs
20	88,200 cfs	54,400 cfs	116,000 cfs
50	115,000 cfs	68,600 cfs	140,000 cfs
100	137,000 cfs	80,300 cfs	158,000 cfs

Adapted from Harza 1999

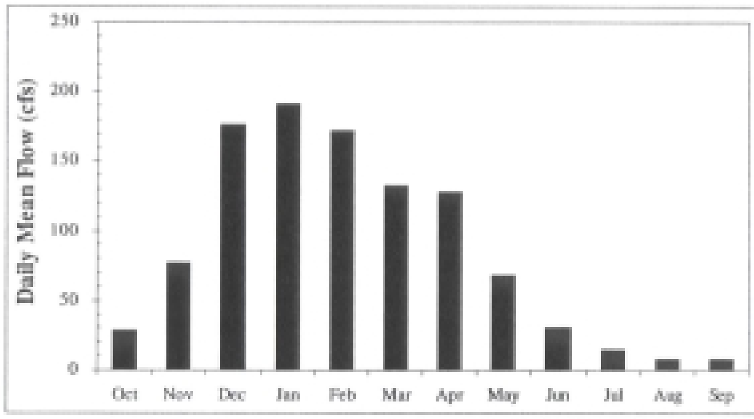
Figure 2: Mean Daily Flow by Month



(a) Tilton River above Bear Canyon Creek near Cinebar, WA (USGS 14236200)



(b) Winston Creek near Silver Lake, WA (USGS 14237500)



Adapted from Harza 1999

Minimum flows have also been affected by the operation of the dams on the Cowlitz. In November 1997, an agreement was reached between Tacoma and the Washington Department of Fish and Wildlife to maintain flows below Mayfield Dam at a level that protects salmon and steelhead resources in the lower Cowlitz mainstem (Harza 1999c).

Other dams and major passage barriers within WRIA 26 include:

- The North Fork Toutle River Sediment Retention Structure Project (SRS) is operated by the Army Corps of Engineers (the Corps) to prevent Mt. St. Helens coarse sediments deposits in the lower watershed. The SRS has filled with coarse bedloads to spillway level. Coarse sediments are expected to flow over the SRS spillway during high flows (LCSCI 1998).
- The North Fork Toutle River - Fish Collection Facility, is just downstream from the SRS, and is operated by WDFW. This facility was installed to collect and separate fish. (LCSCI 1998). TAG members with the WDFW state that the FCF is inoperable much of the time due to sediment that jams the doors. This has occurred at crucial times during adult fish migration, and they have been unable to

allow any adult passage when heavy sediment loads are moving through the system.

- The Barrier Dam is a 12-foot-high, concrete barrier constructed on the Cowlitz River at RM 49.5 in 1969 to divert all adult anadromous migrants into the Cowlitz River Salmon Hatchery. It is the first barrier anadromous fish encounter on the mainstem Cowlitz. Since its completion, the Barrier Dam diverts almost all of the adult migrants into the salmon hatchery. The TAG members state that very few adults get over the Barrier Dam.
- The Mill Creek Hydroelectric Project was constructed in the early 1980s and is operated by Lewis County PUD. It was constructed just over one mile from the mouth and is at or near the historic upstream limit to anadromous fish migration. It operates as a run-of-the-river, non-storage project. (LCSCI 1998).
- The Green River has two hatchery barriers that are a complete block to anadromous fish.
- A private dam on Ferrier Creek is a reported barrier to fish passage (TAG).
- The Blue Creek Hatchery forms a complete block to anadromous fish.
- The Silver Lake Water Level Control Structure on Outlet Creek.

Land Use

Forestry is by far the most dominant land use for all subbasins within WRIA 26 (see Table 6). In the Cowlitz River floodplain below Mayfield, agriculture and other uses made up only 16 percent of land use in 1974 (WDW 1990). Some of the percentages have changed since 1974 due to substantial amounts of residential and industrial development within the basin. The percent increase in population for Cowlitz and Lewis County from 1970 through 1996 was 24% and 31% respectively (Harza 1999c). The most substantial population growth during this period in both counties occurred between 1990 and 1996.

Table 6: Land Use by Percentage in WRIA 26

	Cowlitz above Mayfield	Cowlitz below Mayfield	Toutle	Coweeman	Total
Commercial Forest	71.7%	81.8%	90.2%	94.1%	78.2%
Non-commercial forest	12.8%	0.7	3.0	0.0	7.5
Reserved forest	8.9%	0.0	0.0	0.0	4.8
Cropland	1.7	10.5	2.3	1.4	4.1
Pasture	0.5	4.4	0.4	1.0	1.5
Rural non-farm	0.0	1.0	0.3	0.7	0.3
Built-up land	0.5	1.4	0.2	2.7	0.8
Barren land*	3.9	0.2	3.7	0.0	2.7

*Land in national parks or forests
Adapted from WDW 1990

There is a significant amount of the land base in WRIA 26 in public ownership (see Table 7). Tacoma Power also owns 14,514 acres that are designated as wildlife mitigation lands for the hydroelectric projects on the Cowlitz River (Harza 1999 DEA). Most of the federal and state owned lands are in commercial forestry.

Table 7: WRIA 26 Land Ownership by Percentage

Private acreage (%)	USFS acreage (%)	Nat. Park acreage (%)	BLM acreage (%)	Wa. State acreage (%)	Tribal acreage (%)
51.80	38.60	4.38	0.03	5.10	0.07

EPA summary statistics March 31, 2000 (adapted from Lunetta et.al. 1997).

The earliest and most extensive assessment of fish habitat in the Cowlitz River basin was completed by the Bureau of Fisheries from 1938-1942 (Bryant 1949). These surveys provide exceptional historical information for anyone interested in additional data on the quality and quantity of fisheries habitat within Cowlitz River watershed.

DISTRIBUTION AND CONDITION OF STOCK

The distribution of fall and spring chinook salmon, winter steelhead, coho salmon, and chum salmon was mapped within WRIA 26 at a 1:24,000 scale for this Habitat Limiting Factors Analysis. Maps for each of the anadromous species of interest were developed using a number of existing sources on distribution, such as SASSI (WDF et. al. 1993), StreamNet, WDFW stream surveys, and WDFW spawning surveys (see Appendix A). Members of the WRIA 26 Technical Advisory Group (TAG) added considerably to this existing database with professional experience on WRIA 26 stream systems. For each species, known, presumed, potential, and artificial habitat was mapped (see Appendix C: Fish Distribution Definitions). Table 8: WRIA 26 Fish Distribution and Barriers, represents a compilation of all the fish distribution data that was collected for each stream as well as the number of miles of stream affected by physical barriers. Table 9 displays the same information, but it is summarized by subbasin.

Table 8: WRIA 26 Fish Distribution and Barriers

Stream	**Species Present**					**Miles of Use**				**Artificial, Physical Barriers *** (Miles Affected)		
	SC	*FC*	*Co*	*Ch*	*WS*	Known	*Artif.*	*Pre.*	*Pot.*	*Dikes*	*Culvert*	*Dams*
COWEEMAN SUB.												
Cowlitz River RM 0-20	X	X	X	X	X	20.0				15.9		
Pin Cr.			X		X	2.0				2.0		
Owl Cr.			X		X			1.3				
Coweeman River		X	X	X	X	31.6				3.8		
Unnamed Cr RM 4.1			X		X			0.5				
Unnamed Cr. RM 5.2			X		X			0.3	0.3		0.3	
Turner Cr.			X		X	0.4			2.4		2.4	
Nye Cr.			X		X				0.5		0.5	
Goble Cr.		X	X	X	X	6.8		3.4	0.6		0.6	
N. Fk. Goble Cr.			X		X	3.4		3.4				
Unnamed Cr RM 13.3					X	0.3		0.6				
Unnamed Cr RM 14.2					X				0.6		0.6	
Unnamed Cr. RM 14.6					X				0.7		0.7	
Reid Cr.			X		X	1.7						
Jim Watson Cr.			X		X			0.2				
Sam Smith Cr.			X		X			0.6				
Mulholland Cr.		X	X		X	4.3		0.7				
Unnamed Cr. RM 22.2			X		X			1.2				
Unnamed Cr. RM 23.5					X			0.7				
Baird Cr.			X		X	3.2		1.1	0.7		0.7	
Little Baird Cr.			X		X	0.6			0.9		0.9	
Unnamed Cr. RM 4.5			X		X			0.8				
Nineteen Cr.			X		X			2.6				
Unnamed Cr. (0100)			X		X			0.8				
Skipper Cr.			X		X			2.3				
Brown Cr.			X		X			2.0				
O'Neil Cr.			X		X			3.0				
Marlin Cr.					X			1.1				
Unnamed Cr. RM 30.8			X		X			0.8	0.6		0.6	
Butler Cr.					X			1.0				
Unnamed Cr RM 7.6					X				1.6		1.6	
Unnamed Cr. RM 7.7			X		X				1.3		1.3	
Ostrander Cr.		X	X	X	X	7.2		3.3				
S. Fk. Ostrander			X		X	2.0		7.4	0.5		0.5	
Unnamed Cr. RM 13.1					X				0.7		0.7	

Stream	Species Present					Miles of Use				Artificial, Physical Barriers * (Miles Affected)		
	SC	*FC*	*Co*	*Ch*	*WS*	Known	*Artif.*	*Pre.*	*Pot.*	*Dikes*	*Culvert*	*Dams*
Unnamed Cr RM 13.9					X				0.8		0.8	
Salmon Cr. (0187)			X		X	0.9		4.8				
Unnamed Cr RM 0.6			X		X				0.2		0.2	
LOWER COWLITZ SUBBASIN												
Cowlitz River RM20-52	X	X	X	X	X	32.0				1.4		
Westover Cr.			X		X	1.0		1.3				
McCorkle Cr. (0163)			X	X	X			0.2	1.6			1.6
Leckler Cr.			X		X	3.0						
Arkansas Cr.		X	X	X	X	14.0						
Delemeter Cr.		X	X	X	X	9.3						
Tucker Cr.					X	0.1			0.8		0.8	
Monahan Cr.		X		X	X	6.0						
Baxter Cr.			X	X	X	4.7		0.8				
Whittle Cr.			X		X			5.1				
Rock Cr.			X		X	0.7						
Olequa Cr.		X	X	X	X	13.5						
Stillwater Cr.			X		X	8.2		3.3				
Unnamed Cr RM5.8			X		X				0.3		0.3	
Brim Cr.			X		X			2.7				
Campbell Cr.			X		X			3.0				
Becker Cr.			X		X	2.7						
Duffy Cr.			X		X			0.3				
Snow Cr.			X		X			1.1				
Ferrier Cr.			X		X	0.3			1.5			1.5
Curtis Cr.			X		X	0.9						
King Cr.			X		X	6.6		3.0				
N. Fork Olequa			X		X	2.9		2.3				
Lemur Creek			X		X	0.6		1.8				
Hill Cr.			X		X			0.5				
Lacamas Cr.		X	X	X	X	17.2						
Bear Cr.			X		X	3.8						
Coon Cr.			X		X	2.4						
Mill Cr.			X	X	X	1.5						
Baker Cr.			X		X			1.4				
Foster Cr.			X		X			1.5	2.0		2.0	
Salmon Cr.		X	X	X	X	28.9						
Little Salmon Cr.			X		X	2.3						
Cedar Cr.			X		X			1.4				
Skook Cr.			X		X	1.2			3.7		3.7	
Blue Cr.			X		X	1.1			2.1			2.1
Otter Cr.			X		X	0.8						
Jones Cr.			X		X	0.3			0.1			
Brights Cr.			X		X	2.4						
Mill Cr.			X		X	1.2			5.2			5.2
TOUTLE SUBBASIN												
Toutle River	X	X	X	X	X	16.3						
Unnamed Cr RM 1.8			X		X			0.9				
Unnamed Cr RM 5.2			X		X	1.1			0.8		0.8	
Cline Cr.			X		X	0.3						
Stankey Cr.			X		X	3.2		0.2	5.5		5.5	
Unnamed Cr RM 7.1			X		X	0.9			1.7		1.7	
Rock Cr.			X		X	0.7			2.4		2.4	
Unnamed Cr RM 9.2			X		X				0.4		0.4	
Unnamed Cr RM 10.2			X		X				0.9		0.9	
Unnamed Cr RM 11.2			X		X	0.8		2.4				
Unnamed Cr RM 12.7			X		X	0.6		1.0	0.8		0.8	

Stream	Species Present					Miles of Use				Artificial, Physical Barriers * (Miles Affected)		
	SC	*FC*	*Co*	*Ch*	*WS*	Known	*Artif.*	*Pre.*	*Pot.*	*Dikes*	*Culvert*	*Dams*
Outlet Cr.		X	X		X	3.1						
Unnamed Cr RM			X		X				1.1		1.1	
Silver Lake		X	X		X			6.0				6.0
Hemlock Cr.		X	X		X			3.2				3.2
Unnamed Cr RM1.3			X		X			1.7				1.7
Sucker Cr.		X	X		X			4.3				4.3
South Fork Toutle River	X	X	X	X	X	27.9		1.0				
Studebaker Cr.		X	X		X	3.5		1.7	1.6		1.6	
Johnson Cr.		X	X		X	3.5		4.9	0.8		0.8	
Brownell Cr.			X		X	0.2			0.8			1.5
Jordan Cr.			X		X				0.7			
Thirteen Cr.			X		X	1.1						
Eighteen Cr.			X		X	1.3						
Twenty Cr.			X		X	1.7						
Big Wolf Cr.			X		X	2.1						
Unnamed Cr RM 14.6			X		X			0.2				
Unnamed Cr RM 18.0			X		X			1.3				
Whitten Cr.			X		X			2.5				
Bear Cr.			X		X			3.8				
Herrington Cr.			X		X	2.3						
Little Cow Cr.			X		X			4.3				
Loch Cr.			X		X	1.5						
Trouble Cr.			X		X			3.5				
Unnamed Cr RM 24.3			X		X			1.1				
Fly Cr.			X		X	1.0						
Clancey Cr.			X		X	0.5		1.0				
Disappointment Cr.			X		X	0.5						
Goat Cr.			X		X	2.1						
North Fork Toutle	X	X	X	X	X	12.5						
Wyant Cr.		X	X		X	5.5		0.7	0.7		0.7	
N. Fork Wyant Cr.			X		X	1.5			1.9		1.9	
Mountain Cr.			X		X				1.2		1.2	
Unnamed Cr RM 1.5			X		X			1.4				
Unnamed Cr RM 6.3			X		X				2.8		2.8	
Unnamed Cr RM 7.2			X		X				0.2		0.2	
Nineteen Cr.			X		X	0.2						
Green River	X	X	X		X	24.0						
Beaver Cr.			X		X			1.0				
Jim Cr.			X		X	0.4			1.1		1.1	
Devils Cr.			X		X	5.3						
Cascade Cr.			X		X	1.4						
Elk Cr.			X		X	4.1		2.6				
Schultz Cr.			X		X			3.2				
Tradedollar Cr.			X		X			0.7				
Miners Cr.			X		X			1.3				
North Fork Toutle cont	X	X	X		X	.5	13.9					13.9
Unnamed Cr RM 13.4			X		X		0.7					0.7
Alder Cr.		X	X		X		6.4					6.4
Hoffstadt Cr.		X	X		X		5.4					5.4
Bear Cr.		X	X		X		0.9					0.9
Bear Cr.		X	X		X		5.4					5.4
Deer Cr.		X	X		X		2.8					2.8
Jackson Cr.		X	X		X		1.5**					1.5**
Castle Cr.		X	X		X		2.2					2.2
Coldwater Cr.	X		X		X		1.9					1.9
South Coldwater Cr.	X				X		0.9					0.9

Stream	Species Present					Miles of Use				Artificial, Physical Barriers * (Miles Affected)		
	SC	*FC*	*Co*	*Ch*	*WS*	Known	*Artif.*	*Pre.*	*Pot.*	*Dikes*	*Culvert*	*Dams*
TILTON/ MAYFIELD												
Cowlitz River (cont.)	X	X	X	X	X		11.4					11.4
Winston Cr.							13.0					13.0
Tilton River	X	X	X		X		26.2					26.2
North Fork Tilton			X		X		8.1					8.1
Wallanding Cr.			X		X		1.1					1.1
Otter Cr.			X		X		0.2					0.2
Rockies Cr.			X		X		1.4					1.4
Jesse Cr.			X		X		0.6					0.6
Little Cr.			X		X		0.5					0.5
Connelly Cr.			X		X		3.7					3.7
Coal Cr.			X		X		1.0					1.0
East Fork Tilton			X		X		5.2					5.2
South Fork Tilton			X		X		3.7					3.7
Nineteen Cr.			X		X		0.8					0.8
West Fork Tilton	X		X		X		7.1					7.1
Coon Cr.			X		X		1.4					1.4
Trout Cr.			X		X		1.2					1.2
RIFFE LAKE												
Cowlitz R.M 65.5-88.5	X	X	X	X	X				23.0			23.0
Frost Cr.			X						4.6***			4.6***
Steffen Cr.			X						1.2***			1.2***
Rainey Cr.					X				9.8			9.8
South Fk. Rainey Cr.			X						0.4***			0.4***
Lunch Cr.			X						1.4***			1.4***
Stiltner Cr.			X						1.8***			1.8***
Landers Cr.					X				3.4***			3.4***
Goat Cr.			X						0.3***			0.3***
Tumwater Cr.					X				0.8			0.8
Lambert Cr.					X				3.6			3.6
CISPUS SUBBASIN												
Cispus River	X	X	X		X		33.5					33.5
Quartz Cr.			X		X		2.2					2.2
Crystal Cr.			X		X		2.0					2.0
Woods Cr.			X		X		6.1		1.0		1.0	6.1
Ames Cr.			X				1.9					1.9
Iron Cr.			X		X		1.8					1.8
Greenhorn Cr.			X		X		3.2					3.2
Yellowjacket Cr.	X	X	X		X		6.2					6.2
McCoy Cr.			X		X		0.4					0.4
Camp Cr.			X		X		0.6					0.6
North Fork Cispus	X	X	X		X		5.8					5.8
East Canyon Cr.			X		X		0.2					0.2
Orr Cr.			X		X		2.9					2.9
UPPER COWLITZ SUBBASIN												
Cowlitz River RM 88.5-	X	X	X		X		30.8					30.8
Lambert Cr.			X		X		3.6					3.6
Siler Cr.			X		X		4.0					4.0
Kiona Cr.			X		X		5.1					5.1
Peters Cr.			X		X		1.9					1.9
Oliver Cr.			X		X		1.8					1.8
Miller Cr.			X		X		0.6					0.6
Silver Cr.	X	X	X		X		2.6			.83		2.6

Stream	Species Present					Miles of Use				Artificial, Physical Barriers * (Miles Affected)		
	SC	*FC*	*Co*	*Ch*	*WS*	Known	*Artif.*	*Pre.*	*Pot.*	*Dikes*	*Culvert*	*Dams*
Davis Cr.			X		X		1.7					1.7
Kilborn Cr.			X		X		0.1					0.1
Garrett Cr.			X		X		1.2					1.2
Burton Cr.			X		X		1.9					1.9
Willame Cr.			X		X		1.0					1.0
Smith Cr.			X		X		1.2					1.2
Johnson Cr.	X	X	X		X		3.5					3.5
Hall Cr.			X		X		3.1					3.1
Skate Cr.	X		X		X		10.6					10.6
Butter Cr.			X		X		1.7					1.7
Lake Cr.			X		X		2.0					2.0
Coal Cr.			X		X		0.7					0.7
Muddy Fork Cowlitz	X	X	X		X		3.6					3.6
Ohanapecosh River	X	X	X		X		2.6					2.6
Unnamed Cr RM 133.0			X		X		0.4					0.4
Clear Fork Cowlitz	X	X	X		X		1.3					1.3

SC = Spring Chinook FC = Fall Chinook Co = Coho
Ch = Chum WS = Winter Steelhead Cut = Coastal Cutthroat

Know. = Known Presence Pre. = Presumed Presence Pot. = Potential Presence
Artif. = Artificially placed above a human-made barrier.

(1023) = Stream catalog number

** = Known chinook distribution used.
*** = Coho distribution used

- *Winter Steelhead Distribution was used to denote miles of Known, Presumed, and Potential habitat except where chinook or coho salmon distribution was greater.*

Table 9: Summary of WRIA 26 Fish Distribution and Barriers by Subbasin

Subbasin	Species Present					Miles of Use					Artificial, Physical Barriers (Miles Affected)		
	SC	*FC*	*Co*	*Ch*	*WS*	Know	*Artif*	*Pre.*	*Pot.*	*Total*	*Dikes*	*Culverts*	*Dams*
Coweeman		X	X	X	X	84.4	0	43.1	13.0	140.5	21.9	13.0	0
Lower Cowlitz	X	X	X	X	X	169.6	0	29.7	17.3	216.6	1.4	6.9	10.4
Toutle	X	X	X	X	X	161.6	28.1	49.9	25.4	265.0	0	23.9	1.5
Tilton/Mayfield		X	X		X	0	86.6	0	0	86.6	0	0	86.6
Riffe	X	X	X	X	X	0	50.3	0	0	50.3	0	0	50.3
Cispus	X	X	X		X	0	66.8	0	1.0	67.8	0	1.0	66.8
Upper Cowlitz	X	X	X		X	0	86.0	0	0	86.6	0.83	0	86.0
WRIA 26 Totals	X	X	X	X	X	**415.6**	**267.5**	**173.0**	**56.7**	**912.8**	**24.13**	**95.1**	**301.6**

Fisheries Management

The Cowlitz River is managed for winter and summer steelhead, coastal cutthroat, fall and spring chinook, and coho. Chum salmon are also present, but in extremely low numbers. Until recent years, all salmon stocks were managed as hatchery stocks, and steelhead and most coastal cutthroat were managed as mixed hatchery and natural stocks (WDW 1990; Tipping 2000, personal comm.).

The Cowlitz River may be the most intensively-fished subbasin by the sport-fishery in the state. It has been the top winter steelhead river in Washington, and the Toutle was in the top five before the 1980 eruption of Mt. St. Helens. Both rivers are also popular summer steelhead streams. In good return years, the Cowlitz attracted immense angler effort for spring chinook. Both the Cowlitz and Toutle attracted considerable angler effort for fall chinook and coho (WDW 1990).

The earliest quantitative assessments of anadromous fish in the Cowlitz Basin were conducted in 1955 and 1956 using downstream migrant traps and spawning-ground surveys (Stockley 1961).

Until 1981, some spring chinook, coho, and steelhead adults were trucked above Mayfield to the Tilton River, and above Mossyrock to the Cowlitz River, to provide a limited sport fishery. In 1981, IHN virus (infectious hematopoietic necrosis) was detected in Cowlitz winter steelhead, and transportation of steelhead and chinook above Mayfield Dam was terminated so the Cowlitz Salmon Hatchery water supply would not be contaminated with the virus. Coho have not been observed to host the virus in the Cowlitz, so coho adults and jacks are usually planted in the Tilton River and upper Cowlitz each year (WDW 1990).

Currently, the anadromous reintroduction plan is to trap and haul native (late) winter steelhead, coho, and coastal cutthroat to the Mayfield/Tilton, Upper Cowlitz, and Cispus subbasins. The reintroduction program also includes transporting spring chinook above the Cowlitz Falls Dam. Out-migrating juveniles from above the Cowlitz Falls Dam are collected at the Cowlitz Falls Fish Facility and are trucked below Barrier Dam. Out-migrants from the Tilton and Mayfield subbasin are passed downstream in a flume. There are currently no plans to reintroduce fall or spring chinook to the Tilton River, but there are plans to reintroduce fall chinook above the Cowlitz Falls Dam in the future (Wolf Dammers 2000, personal comm.; John Serl 2000, personal comm.).

Stock Descriptions

Spring Chinook *(Oncorhynchus tshawytscha)*

Historically, spring chinook were abundant in the Cowlitz River upstream from the Mayfield Dam site. Most of the spawning took place on the Cowlitz above Packwood and in the Cispus River (WDF 1951). By the early 1900's, Columbia River salmon populations were declining from overfishing and a combination of land use practices that proved detrimental to salmon habitat (WDFW 1998; vol. 1). In 1948, an estimated 32,490 adult spring chinook were produced annually in the upper Cowlitz River, with an estimated spawning escapement of 9,000 fish above the dam site (WDF/WFC 1948). In the early 1950s, the estimated annual spawning escapement was 10,900 spring chinook, with a distribution estimated to be 400 fish in the upper Toutle River, 200 fish in the Tilton River, 8,100 in the Cispus River, and 1,700 in the upper Cowlitz (a total of 10,000 above the dam site)(WDF 1951). Spring chinook were not found in the Tilton after about 1950 (Thompson and Rothfus 1969). Ninety-six percent of the spring chinook production in the Cowlitz River was estimated to have occurred above Mayfield Dam from 1950 to 1961 (Easterbrooks 1980).

From 1974 through 1980, an average of 2,838 spring chinook adults from the Cowlitz Salmon Hatchery were trucked to the Tilton and upper Cowlitz rivers for the sport fishery and natural production. The program was discontinued due to the risk of IHN-virus contamination of the water supply at the Cowlitz Salmon Hatchery (WDF et. al. 1993). The pre-eruption (1977-1979) harvest of spring chinook was estimated at 99 percent in the Cowlitz and 1 percent in the Toutle (WDW 1990).

The Cowlitz Salmon Hatchery mitigation goal is to return 17,300 spring chinook adults to the hatchery each year. This is based on the highest return to the upper Cowlitz in 1965, when 17,274 fish were trapped at the Mayfield fish facilities. The jack returns that year was 3,487, for a total of 20,761 returning spring chinook (Easterbrooks 1980). Between 1983 and 1992, the average annual escapement to the hatchery and Cowlitz River was 11,573, and has ranged from 6,417 fish in 1990 to 18,302 fish in 1983. Spring chinook were planted above the Cowlitz Falls Dam in 1995. From 1996 to the present, WDFW began collecting juveniles at Cowlitz Falls Fish Collection Facility and trucked them below Barrier Dam (John Serl 2000, personal comm.). WDFW continues to truck adults above the Cowlitz Falls Dam as part of the anadromous reintroduction program. There are no plans to reintroduce chinook to the Tilton River.

Spring chinook in the Cowlitz River are a hatchery stock of mixed origin, and very few individuals are produced from natural spawning (see Table 11)(WDF et. al. 1993). Stock mixing likely began when hatchery supplementation was initiated in 1967 at the salmon hatchery below Mayfield Dam (WDF et. al. 1993). Most of the natural spawning on the Cowlitz River occurs in an 8-mile reach between the Cowlitz Salmon and Trout hatcheries (WDF et. al. 1993). Fall chinook spawn in the same areas and redd superimposition occurs (WDW 1990). A hatchery program for spring chinook was established at Cowlitz Salmon Hatchery in 1968. Naturally-spawning Cowlitz River spring chinook are hatchery fish that did not enter the facilities (Tipping 2000 personal comm.). Cowlitz River spring chinook stock status was listed in SaSSI (WDF et. al. 1993) as "healthy" based on escapement trends (see Table 10), but the stock status is considered depressed now, as the stock may not reach hatchery spawning escapement needs in 2000 even with a fishery closure (Tipping 2000: personal comm.) Natural spawning escapement from 1980-1991 averaged 389 fish, with a low of 90 in 1987 and a peak of 1,116 in 1981. Maximum adult production potential above the dams was estimated to be 55,555 by Beck (1982) and 57,052 by Easterbrooks (1980).

Toutle River Spring Chinook

Toutle River spring chinook are not recognized by WDFW as a separate stock (WDF ET. AL. 1993). In the early 1950s, annual spawning escapement was estimated to be 400 fish in the upper Toutle River (WDF, 1951). The current estimated return is 164 fish (WDW 1990). The Toutle Hatchery produced spring chinook from 1967 until 1980, when it was destroyed by the Mt. St. Helens mudflows (WDW 1990). Most Toutle spring chinook were reared in Deer Springs Pond, which was destroyed in the winter of 1981-82 when a temporary flood-control dam was breached. Evaluation of the fish plants was not conducted, and returning adults were not captured at the hatchery. The primary management objective for the Toutle River is to produce 500 fish for the sport harvest. This would represent an estimated subbasin return of 1,697 fish and a total production of 2,976 fish (WDW 1990).

Table 10: WRIA 26 Spring Chinook SaSSI Stock Status

Stock	Screening Criteria	1992 SASSI Stock Status	Estimated Status (2000)	Status (ESA Listing)
Cowlitz	Escapement Trend	Healthy	Depressed (Tipping 2000 personal comm.)	Federal “Threatened”

Adapted from WDF et. al. 1993.

Table 11: WRIA 26 Spring Chinook Stocks

Stock	Stock Origin	Production Type
Cowlitz	Mixed	Composite

Adapted from WDF et. al. 1993.

Summer Chinook (*Oncorhynchus tshawytscha*)

The original separation of chinook into spring and fall races was an arbitrary determination by hatchery personnel reached by imposing an arrival-at-hatchery date of July 31 and then declaring those chinook arriving at the hatchery prior to that date to be "spring chinook" and those arriving at the hatchery after it "fall chinook" (Senn, H. 1993, Response to Draft 1: Cowlitz Falls Project Fisheries Management Plan). This method ignores the entry time of summer chinook adults, which is the criterion used by field managers to determine race. As a result, summer chinook have been mixed with both spring and fall races. Full utilization of the upper-river habitats available could well require the use of all races of chinook. While spawning temporal distributions are not now apparent, certainly there were spatial separations among the components of the races that may allow the eventual reconstruction of three discrete, chinook-spawning components in terms of time and/or space. This within-species diversity may be of importance to the populations and their ability to maintain themselves under a host of conditions. When the fish are allowed to breed where they choose and migrate at will, it is expected that a summer component will develop. Agencies are leaving open the option to introduce all races, depending on how the program progresses (Gaia NW, Inc. 1993)

Fall Chinook (*Oncorhynchus tshawytscha*)

Fall chinook are indigenous and historically were abundant in the Cowlitz Basin (WDW 1990). In 1951, the fall chinook escapement to the Cowlitz River and tributaries was estimated at 31,000, with the following distributions: 10,900 to the mainstem Cowlitz and its minor tributaries, 8,100 to the Cispus, 500 to the Tilton, 6,500 to the Toutle, and 5,000 to the Coweeman (WDF 1951).

Cowlitz River Fall Chinook

Historically, fall chinook spawning occurred throughout the area available to anadromous fishes, from the first favorable gravel riffle to the headwaters (WDF 1951). They migrated to and spawned within all the major tributaries to the Cowlitz, several of the smaller tributaries, as well as the main river. In 1948, the WDF and WDG estimated that the upper Cowlitz River produced 63,612 adult fall chinook annually. Escapement above the Mayfield Dam site was believed to be "no less than 14,000 fish".

In 1951, WDF estimated that the annual escapement of fall chinook to the Cowlitz River totaled 31,000. The distribution was thought to be 10,900 to the mainstem Cowlitz and "minor tributaries," 500 in the Tilton River, 8,100 to the Cispus (WDF 1951). Most of the spawning was reported to occur in the mainstem Cowlitz near Randle, and in the Cispus and Tilton rivers (Thompson and Rothfus 1969; WDF/WGC 1948; WDF 1951).

Forty-six percent of the fall chinook run in the Cowlitz River was estimated to have come from above Mayfield Dam in 1950 to 1961, and 28 percent of the spawning grounds were inundated by Mayfield and Mossyrock reservoirs (Easterbrooks 1980). Redd counts from 1961 through 1966 indicated returns to the Cowlitz River would have been 23,067 fish (WDW 1990). In 1961 through 1966, an annual average of 5,992 adult and 2,543 jack fall chinook were counted at Mayfield Dam (Thompson and Rothfus 1969).

All fish were passed over the dams from 1962 to 1966. From 1967 to 1980, only small numbers of fall chinook were hauled to the Tilton River and upper Cowlitz. Since 1980, only a small number of jacks have been passed upstream due to the inability to achieve hatchery spawning needs (WDF et. al. 1993).

In the 1980s, fall chinook spawned primarily in the eight-mile stretch between the Cowlitz Trout Hatchery and the Cowlitz Salmon Hatchery (85 percent of the natural escapement in 1983), although there were over 30 miles of suitable spawning habitat available below the Cowlitz Salmon Hatchery. Based on coded-wire recoveries, hatchery-produced fish dominate the system's production (DeVore 1987).

Table 12 summarizes both observed and estimated wild adult fall chinook returning to the Cowlitz River from approximately 1820 to the present. Estimates were produced using the Ecosystem Diagnosis and Treatment Method (EDT), (Mobrand Biometrics 1999).

Table 12: Comparison of estimates of adult fall chinook run sizes.

Area	EDT Model Template (~1820)	Observed 1950s[1]	Observed 1960s[2]	Observed 1991-1995[3]	EDT Model Current
Lower Cowlitz mainstem	65,700	540	360	0	0
Mid Cowlitz mainstem	23,400	9,050	6,060	1,530	1,000
Below Dams	***89,100***	***9,590***	***6,420***	***1,530***	***1,000***
Reservoirs	7,300	2,360	1,580	0	0
Tilton system	5,400	250	170	0	0
Cispus system	7,100	2,520	1,690	0	0
Upper Cowlitz mainstem & forks	7,000	3,300	2,210	0	0
Above Dams	***26,800***	***8,430***	***5,650***	***0***	***0***
Total Natural	**115,900**	**18,020**	**12,070**	**1,530**	**1,000**
Cowlitz Hatchery returns	---	---	---	5,360	4,000

Estimates of run sizes for the 1950s and 1960s represent spawning escapements and do not include sport harvests.
1, WDF 1951.
2. Thompson and Rothfus 1969.
3. Harza 1999c.

The EDT analysis attributes the extreme loss in major production from the lower Cowlitz, downstream of the Toutle, to major human-caused changes to the river channel, such as dredging, diking, and straightening. The EDT analysis states that "uncertainty exists with all of the run-size estimates discussed, and the results must be applied with caution; however, the pattern seen in the table above is troubling" (Mobrand Biometrics 1999).

The Cowlitz River fall chinook natural spawners are a mixed stock of composite production (see Table 14). While SaSSI stock status (WDF et. al. 1993) was listed as healthy (see Table 13), current fall chinook stocks are considered depressed by WDFW (Tipping 2000, personal comm.). Natural spawning escapements from 1967-1991 averaged 6,778 (WDF et. al. 1993), but they have since declined to about 2,600 fish per year (Tipping 2000, personal comm.). Most of the spawning takes place between the Kelso Bridge and the Cowlitz Salmon Hatchery (WDF et. al. 1993). In 1987, DeVore estimated that naturally-spawning fish comprise just over ten percent of adult returns.

The Cowlitz River, downstream of Barrier Dam to the Toutle River is the only section of the basin included in the EDT analysis that sustains fall chinook production (excludes the Toutle and Coweeman watersheds). Widely different distribution potentials between historic and current conditions were projected. Much of this difference is due to the fish-passage barrier created by the mainstem dams (Mobrand Biometrics 1999). WDFW has plans to reintroduce fall chinook above the Cowlitz Falls Dam in the future, but there are no plans to reintroduce chinook to the Tilton River (John Serl 2000, personal comm.).

The Cowlitz Salmon Hatchery mitigation goal is to return 8,300 fall chinook adults to the hatchery each year. Between 1983 and 1992, the average annual escapement to the hatchery and Cowlitz River was 11,666 and has ranged from 3,778 fish in 1992 to 20,071 fish in 1988 (Harza 1999c). Maximum adult production potential in the upper Cowlitz watershed was estimated to be 63,818 by Beck (1982) and 93,015 by Easterbrooks (1980).

Coweeman River Fall Chinook

Historically, fall chinook spawned from Mulholland Creek (RM 18.4) downstream approximately 6 miles to the Jeep Club Bridge (WDF et. al. 1993). The estimated annual escapement of fall chinook in 1951 was 5,000, although splash dams probably impacted production (WDW 1990).

The Coweeman River has received fall chinook plants from at least 1951 until 1979 (WDW 1990). The Coweeman River fall chinook are a mixed stock of composite production (see Table 14). Fall chinook have been planted in the Coweeman River since 1951. SaSSI (WDF et. al. 1993) listed fall chinook stocks as healthy in 1993; however, the status today is unknown. Natural spawning escapements from 1967-1991 averaged 182 with a low of 38 in 1981 and a high of 1,108 in 1988 (WDF et. al. 1993). Coweeman River fall chinook are presently managed as a lower Columbia River hatchery stock (WDW 1990).

Toutle River Fall Chinook

The following information refers to fall chinook in the mainstem Toutle and North Fork Toutle Rivers. The SaSSI report (WDF et. al. 1993) does not specifically refer to fall chinook stocks in these streams, but does recognize South Fork Toutle and Green River stocks.

The estimated annual escapement of fall chinook in the Toutle and its tributaries in the early 1950s was 6,500. An estimated 80 percent of the total Toutle fall chinook run spawned in the lower five miles of the mainstem Toutle (WDF 1951).

Annual surveys show the greatest abundance of adult fall chinook on the North Fork Toutle River to be in a five-mile stretch from the Toutle River Hatchery (1/2 mile up the Green River) to Kid Valley Park on the North Fork Toutle. An average spawning escapement of 2,700 fall chinook was observed from 1968 to 1972, with a sharp increase beginning in 1971. Fall chinook were observed as far upstream as Spirit Lake (WDF 1973).

An average of 10,756 adults returned each year to the Toutle River basin from 1964 through 1979 (pre-eruption). Of these, natural spawners of both hatchery and natural origin in the Toutle subbasin averaged 6,573 fish from 1964 through 1979 with the following distribution: 4.8 percent from the mainstem, 3.8 percent South Fork Toutle, 49.4 percent North Fork Toutle, and 42 percent Green River (Kreitman 1981 as cited in WDW 1990). The Toutle River has been stocked with fall chinook since at least 1951 until 1980 (WDF 1990). Spawning areas in the mainstem Toutle, North Fork, and Green rivers were destroyed by the 1980 eruption of Mt. St. Helens (WDW 1990).

DeVore (1987) assumed that 12.8 percent of the Toutle River fall chinook spawned naturally and estimated that an average of 1,528 naturally-spawning fall chinook entered the Toutle subbasin.

South Fork Toutle River Fall Chinook

Fall chinook are native to the South Fork Toutle River. Natural spawners from 1964 through 1979 were, on average, 3.8 percent of the Toutle subbasin spawners (Kreitman 1981 as cited in WDW 1990).

The South Fork Toutle fall chinook natural spawners are an unknown stock of composite production (see Table 14). They currently spawn in the South Fork Toutle in the 2.6 miles from the 4700 Bridge (RM 2.6) to the confluence with the mainstem Toutle River. Current fall chinook stocks are considered depressed and show signs of a long-term negative trend (WDF et. al. 1993). Natural spawning escapements from 1967-1979 averaged 257 fish with a low of 42 in 1968 and a high of 578 in 1971. Post eruption escapements in 1980 and 1981 were zero and 81 fish, respectively. Spawning ground counts were suspended until 1991, when the escapement was 33 fish (WDF et. al. 1993).

Green River Fall Chinook

Fall chinook are native to the Green River. About 20 miles of spawning and rearing area are available above the hatchery trap on the Green River (excluding tributaries). (WDF 1973).

Natural spawners (hatchery and natural origin) from 1964 through 1979 averaged 42 percent (equal to 4,517 fish) of the Toutle subbasin spawners, which were estimated at 10,756 fish (Kreitman 1981 as cited in WDW 1990). The spawning grounds were destroyed by the 1980 eruption of Mt. St. Helens. The Toutle River Hatchery, located 0.5 miles up the Green River, began collecting brood stock again in 1990. Surplus hatchery fish were released upstream of the hatchery to spawn naturally. Brood stock has been from a mixture of sources since the 1980 eruption (WDW 1990).

The Green River fall chinook natural spawners are an unknown stock (see Table 14). Natural spawning escapements from 1967-1979 averaged 3,025 fish with a low of 948 in 1977 and a high of 6,654 in 1972. Post eruption escapements in 1980 and 1981 were zero and 10 fish, respectively. Spawning ground counts were suspended until 1990, where the escapement was 123 fish in 1990 and 126 in 1991. They spawned in the 0.5 mile reach from the mouth to the Toutle River Hatchery. Natural fall chinook stocks were listed as depressed (see Table 13) in SaSSI and show signs of a long-term negative trend (WDF et. al. 1993).

Table 13 - WRIA 26 Fall Chinook SaSSI Stock Status

Stock	Screening Criteria	1992 SASSI Stock Status	Estimated Status (2000)	Status (ESA Listing)
Cowlitz	Escapement Trend	Healthy	Depressed (Tipping 2000 personal comm.)	Federal "Threatened"
Coweeman	Escapement Trend	Healthy	Depressed (Tipping 2000 personal comm.)	Federal "Threatened"
South Fork Toutle	Escapement Trend	Depressed	Depressed (Tipping 2000 personal comm.)	Federal "Threatened"
Green	Escapement Trend	Depressed	Depressed (Tipping 2000 personal comm.)	Federal "Threatened"

Adapted from WDF et. al. 1993.

Table 14 - WRIA 26 Fall Chinook Stocks

Stock	Stock Origin	Production Type
Cowlitz	Mixed	Composite
Coweeman	Mixed	Composite
South Fork Toutle	Unknown	Composite
Green	Unknown	Composite

Adapted from WDF et. al. 1993.

Coho Salmon (*Oncorhynchus kisutch*)

Coho are indigenous to the Cowlitz Basin, and were historically abundant almost throughout the watershed (WDF 1951). Annual counts of coho indicate this species is the most abundant salmon in the Cowlitz River system. Bryant (1949) called the Cowlitz River system, "the greatest silver salmon producing area in the entire Columbia River watershed."

Historically, two separate runs of coho were reported to enter the Cowlitz River. The early run (Type-S) entered the Cowlitz from late August and September with a spawning peak in late October, and the late run (Type-N) entered from October through March with a spawning peak in late November (WDG/WFC 1948). Type-S and Type-N were named for stocks either turning south or north upon reaching the Pacific Ocean. In the early 1950s, the spawning escapement was estimated at 16,000 early coho and 16,500 late coho for a total of 32,000 fish (WDF 1951).

The mitigation goal for fish returning to the Cowlitz Salmon Hatchery is 25,500 coho, which is equivalent to 53,600 jacks and adults (WDW 1990).

Cowlitz River Coho

In 1948, the estimated annual escapement of coho to the Cowlitz River basin was 77,000. Of this total, 24,000 (31 percent) of the Cowlitz River coho were estimated to have come from above Mayfield Dam (WDF/WGC 1948). Shortly thereafter in the early 1950s, the estimated annual escapement for the Cowlitz River basin was 32,500 fish (WDF 1951). From 1950 to 1961, 77 percent of the coho run in the Cowlitz River was estimated to come from above Mayfield Dam (Easterbrooks 1980). Between 1961 and 1966, an average of 24,579 adult coho were collected at the Mayfield Dam fish collection facility. (Thompson and Rothfus 1969). All fish were passed over the dams until 1967. From 1967 to 1980, a portion of the coho run was hauled to the Tilton River and upper Cowlitz. In 1981 and 1982, transport was temporarily interrupted, then resumed in 1983. From 1980 until reintroduction efforts resumed, adult and jack coho salmon plants were the only sport fishery of anadromous salmon above Mayfield Dam (Stober 1986). Reintroduction in the upper Cowlitz basin resumed in 1995 and is continuing. Juveniles are collected at the Cowlitz Falls Dam trucked below the Barrier Dam (John Serl 2000, personal comm.). Tilton River downstream migrants are passed through Mayfield Dam. Adults are trucked above Cowlitz Falls Dam and into the Tilton River (Wolf Dammers 2000, personal comm.).

Cowlitz River coho are managed for a large range of return timing; but all are considered to be of "Type-N", or late-returning stock. However, Meekin (1962) reported significant early runs of coho in the upper Cowlitz index areas. Results for the five years of data collected for each run show a higher count for early coho in 3 of the 5 years (Meekin 1962). The Type-N stock returns after the fall chinook season, so their harvest in the Columbia River gill-net fishery was not affected by chinook conservation efforts. The Type-N stock has dominated Cowlitz Hatchery production because catch distribution favors the Washington ocean fishery (WDW 1990).

Most coho in the Cowlitz River basin are of hatchery origin. DeVore (1987) accounted for the 1982-brood hatchery release and concluded wild/natural production was minor. Of the 4,635 naturally-spawning coho in the Cowlitz in 1985, an estimated 91% were hatchery smolt releases, and hatchery fingerling releases could account for the additional naturally-spawning fish. Hatchery coho have been planted in the Cowlitz since at least 1915, when the Tilton River Hatchery operated downstream of Morton until 1921. Stock mixing probably began in 1915 (DeVore 1987).

Since 1968, the Cowlitz Salmon Hatchery has been producing coho salmon. The mitigation goal is to maintain annual hatchery returns of 25,500 coho adults to the hatchery. Between 1983 and 1992, the average annual escapement to the hatchery and Cowlitz River was 28,572, and has ranged from 13,009 fish in 1990 to 54,685 fish in 1995 (Harza 1999b).

The Cowlitz River coho are a mixed stock of composite production (see Table 16). Current coho stocks are considered depressed (see Table 15)(WDF et. al. 1993). Most of the natural spawning takes place in Olequa Creek, with smaller numbers spawning in

Ostrander, Arkansas, Stillwater, Campbell, Foster, Hill, Lacamas, Brights, Blue, Otter, and Mill creeks (WDF et. al. 1993). Estimates of coho production potential in the Cowlitz River basin above the dams range from 6,319 (Stockley 1961) to 261,254 (Easterbrooks 1980).

Coweeman River Coho

Little is known of historic or present status of Coweeman coho (WDW 1990). Currently, the most extensively used spawning area is in the 8-mile section below the confluence of Mulholland Creek (WDF et. al. 1993). The number of naturally spawning coho in the Coweeman is presumed to be quite low, estimated at 200 fish. The annual escapement of hatchery coho in the Coweeman is estimated to be 300 fish (WDW 1990). Historically, Coweeman coho were considered an early (Type-S) stock. Currently, Coweeman coho consist of both "early" and "late" coho, due to hatchery manipulation to meet harvest-management requirements (WDF et. al. 1993). Goble, Mulholland, and Baird creeks have good coho production potential.

The Coweeman River coho are a mixed stock of composite production (see Table 16). Current coho stocks are considered depressed (see Table 15)(WDF et. al. 1993). Natural spawning escapements from WDFW are not available.

Toutle River Coho

Coho are native to the Toutle River, were historically abundant, and were present throughout the watershed. Historically, they spawned in all accessible tributaries. A major portion of the spawning area was destroyed by the 1980 eruption of Mt. St. Helens (WDF et. al. 1993).

Toutle River coho were, generally, an early-returning stock (Type-S), with most fish returning from August through October. Late runs are also present. Early Toutle River coho are generally more southerly distributed in the ocean than the early component of the Cowlitz stock (WDW 1990).

The naturally spawning Toutle coho are an unknown stock of composite production (see Table 16). They currently spawn in all accessible tributaries. Current coho stocks are considered depressed and show signs of a long-term negative trend (see Table 15)(WDF et. al. 1993). The run-size of naturally spawning fish for 1972-1979 was estimated to be 1,662 fish, based on average rack returns of 14,406 fish (WDW 1990). Adult coho are trapped and hauled above the sediment-retention dam on the North Fork Toutle (WDW 1990). Hatchery fingerlings were seeded in the watershed beginning in 1983 and this continued as least until the writing of the SaSSI report in 1993. Coho production by hatcheries is attempting to include both "early" and "late" coho to meet harvest-management requirements. A number of tributaries in the Toutle River have good production potential; among these are Stankey and Outlet creeks (WDF et. al. 1993).

South Fork Toutle River Coho

Coho are native to the South Fork Toutle River and spawn throughout the river and its tributaries. Some spawning areas were destroyed by the 1980 eruption of Mt. St. Helens (WDF et. al. 1993).

South Fork Toutle coho natural spawners are a mixed stock of composite production (see Table 16). Current coho stocks are considered depressed based on chronically-low production (see Table 15)(WDF et. al. 1993). Naturally spawning escapement estimates are not available. Hatchery coho production includes both "early" and "late" coho to meet harvest-management requirements. A number of tributaries in the Toutle River have good production potential. Among these are Johnson, Studebaker, Disappointment, and Herrington creeks (WDF et. al. 1993).

Green River Coho

Coho are native to the Green River and historically spawned in all accessible tributaries. Both early and late runs existed in the Green River (Meekin 1961). Some spawning grounds in the lower Green River were destroyed by the 1980 eruption of Mt. St. Helens (WDF et. al. 1993).

Table 15 - WRIA 26 Coho Stock Status

Stock	**Screening Criteria**	**1992 SASSI Stock Status**	**Status (ESA Listing)**
Cowlitz	Escapement Trend	Depressed	Federal “Candidate”
Coweeman	Escapement Trend	Depressed	Federal “Candidate”
Toutle	Escapement Trend	Depressed	Federal “Candidate”
South Fork Toutle	Escapement Trend	Depressed	Federal “Candidate”
Green	Escapement Trend	Depressed	Federal “Candidate”

Adapted from WDF et. al. 1993.

Table 16 - WRIA 26 Coho Stocks

Stock	Stock Origin	Production Type
Cowlitz	Mixed	Composite
Coweeman	Mixed	Composite
Toutle	Mixed	Composite
South Fork Toutle	Mixed	Composite
Green	Mixed	Composite

Adapted from WDF et. al. 1993.

Green River coho natural-spawners are a mixed stock of composite production (see Table 16). Current coho stocks are considered depressed based on chronically-low production (see Table 15)(WDF et. al. 1993). Natural spawning escapements are not available but believed to be quite low. Hatchery coho production includes both "early" and "late" coho to meet harvest-management requirements. A number of tributaries in the Toutle River have good production potential. Among these are Devils, Elk, and Schultz creeks (WDF et. al. 1993).

Winter Steelhead (*Oncorhynchus mykiss*)

There is little or no information available to indicate that lower-Columbia winter steelhead stocks are genetically distinct from one another. The stocks are treated separately by WDFW due to geographical isolation of spawning populations (WDF et. al. 1993).

Winter Steelhead are indigenous to the Cowlitz Basin, were historically abundant, and probably present throughout the watershed (WDW 1990). Between 1961 and 1966, WDF collected an annual average of 11,081 adult steelhead at the Mayfield fish passage facility (Meekin and Birtchet 1963; Thompson and Rothfus 1969). After the construction of Mossyrock Dam in 1968, wild steelhead returns plummeted due to lack of juvenile outmigration and adult upstream passage (LCSCI 1998). It is estimated that wild steelhead production in the mainstem Cowlitz is minimal, but that key wild production areas still exist lower river tributaries such as Olequa Creek (LCSCI 1998).

Cowlitz River Winter Steelhead

The estimated annual production of winter steelhead in the upper Cowlitz River in 1948 was 22,000, with an estimated escapement of 11,000 (WDG/WFC 1948). Between 1961-62 and 1965-66 an average of 11,081 adult steelhead were collected at the Mayfield Dam fish collection facility with a low of 8,821 in 1962-63 and a high of 13,155 in 1964-65 (Thompson and Rothfus 1969).

Winter steelhead were known to spawn in the mainstem Cowlitz River near Riffe and in a reach from the mouth of the Muddy Fork to the mouth of the Clear Fork (Kray 1957). Substantial spawning was also observed in the Tilton and lower Ohanapecosh rivers (Kray 1957). Approximately 80 percent of the historic winter steelhead spawning and rearing areas were above the dams (WDF et. al. 1993).

All fish were passed over the dams until 1967. Prior to 1981, an annual average of 3,466 steelhead were trucked above Mayfield into the Tilton River to provide a sport fishery, although a few fish spawned naturally in the river (Stober 1986). Most fish dropped out of the river and the sport catch was only 6 percent of the transported adults. In 1981, steelhead were retained below Mayfield Dam due to the concern of contaminating the Cowlitz Salmon Hatchery with the IHN virus (WDW 1990).

Adults entering the hatchery or Barrier Dam separator are recycled back to the river to increase harvest opportunity (WDW 1990). Between 1983 and 1995, the average annual escapement of Cowlitz River winter steelhead was 16,240, and has ranged from 4,067 fish in 1983 to 30,200 fish in 1995 (Harza 1999c). As part of the WDFW/Tacoma City Light mitigation agreement, WDFW is managing for 750,000 smolts, which are to provide a return of 22,000 adults and a sports catch of 15,400 fish (WDW 1990). Reintroduction of winter steelhead in the upper Cowlitz basin resumed in 1994 and is continuing. Juveniles have been collected at the Cowlitz Falls Dam since 1996 and trucked below the Barrier Dam (John Serl 2000, personal comm.). Adult steelhead are trucked into the Tilton River, and juveniles are counted at Mayfield Dam and then passed downstream (Wolf Dammers 2000, personal comm.).

Currently, the Cowlitz Trout Hatchery is the primary source of winter steelhead production in the Cowlitz River. In 1990, it was estimated that naturally-spawning steelhead below Barrier Dam were less than two percent of the total run (WDW 1990). A spawning escapement survey, conducted in 1985, estimated that 5,703 winter steelhead spawned below Mayfield Dam (Tipping et. al. 1985).

The naturally-spawning Cowlitz River winter steelhead are a mixed stock of wild production. The average percent of hatchery spawners is approximately 92% (see Table 19)(LCSCI 1998). The stock is considered depressed based on chronically low returns (see Table 18)(LCSCI 1998). Most of the natural spawning takes place in Olequa, Ostrander, Salmon, Arkansas, Delameter, and Monahan creeks (WDF et. al. 1993). The primary limiting factor for steelhead production on the Cowlitz River is lack of suitable spawning and rearing habitat due to construction of Mayfield Dam in 1963 (WDF et. al. 1993). Restoration of the steelhead population upstream of Cowlitz Falls Dam should provide an estimated 6,000 to 7,000 wild adult steelhead (WDF et. al. 1993).

Table 17: Comparison of estimates of Cowlitz River wild, winter steelhead run sizes (excluding the Toutle and other tributaries in lower basin)

Area	**EDT Model Template (~1820)**	**Observed 1960s[1]**	**Observed 1980s[2]**	**EDT Model Current**
Lower Cowlitz main-stem and small tributaries	3,810	Not Available	1,030	370
Mid Cowlitz mainstem	5,540	Not Available	310	550
Below Barrier Dam	*9,350*		*1,340*	*920*
Reservoirs	870		0	0
Tilton system	1,520		0	0
Cispus system	1,350		0	0
Upper Cowlitz mainstem & forks	1,600		0	0
Above Barrier Dam	*5,340*	*<11,100*[3]	*0*	*0*
Grand Total	14,690	12,070	1,530	920

1. Thompson and Rothfus, 1969.
2. WDW, 1990.
3. Estimates upstream of Barrier Dam during the 1960s are believed to consist of a significant number of hatchery fish; therefore, the wild-run estimate is considered less than 11,100.

Estimates for mean escapement of winter steelhead for the Cowlitz River are not yet available; however, it is estimated that from 1991 to 1996, 8 percent of the run were wild fish (LCSCI 1998). WDW (1990) estimated the percentage of wild fish at 1.7 percent of the total run size in the Cowlitz River, based on catch sampling. This does not include fish returning to the Toutle and Coweeman subbasins, and may underestimate the very late component of the wild run following the return of hatchery fish (Mobrand Biometrics 1999). It is estimated that wild steelhead production in the lower Cowlitz is minimal, but key wild production areas exist in lower-river tributaries (LCSCI 1998).

Table 17 summarizes both observed and estimated wild steelhead returning to the Cowlitz River from approximately 1820 to the present. Estimates were produced using the Ecosystem Diagnosis and Treatment Method (Mobrand Biometrics 1999). This table does not include fish returning to the Toutle and Coweeman subbasins, and may underestimate the very late component of the wild run, following the return of hatchery fish (Mobrand Biometrics 1999).

Coweeman River Winter Steelhead

The Coweeman River has been planted with hatchery steelhead since 1957 (WDF et. al. 1993). These fish were intended to supplement the sport fishery. No historical production estimates are given for this stock. Currently, winter steelhead spawning occurs throughout the basin (WDF et. al. 1993). Coweeman River winter steelhead are a mixed stock of wild production (Tipping 2000, personal comm.). While hatchery steelhead smolts have been stocked in this and nearby streams, there is little contribution to the wild winter steelhead stock from hatchery fish spawning in the wild (WDF et. al. 1993). The Coweeman stock is managed for both natural and hatchery production (WDW 1990). Winter steelhead stocks are currently considered depressed based on chronically low returns (see Table 18)(LCSCI 1998). Spawning escapements were estimated from 1987 through 1990, with a low of 392 in 1989 and a high of 1,088 in 1988. The escapement goal of 1,064 wild steelhead was exceeded only during 1988 (WDF et. al. 1993). The mean estimated escapement from 1991 to 1996 was 351 fish. It is estimated that from 1991 to 1996, 27 percent of the run were hatchery fish (LCSCI 1998).

Mainstem/North Fork Toutle River Winter Steelhead

The mainstem North Fork Toutle River has been planted with hatchery steelhead since 1953 (WDF et. al. 1993). No historical production estimates are given for this stock. Currently, winter steelhead spawning occurs in Hoffstadt, Outlet, Alder, and Deer creeks (WDF et. al. 1993). The mainstem North Fork Toutle winter steelhead are a mixed stock of wild production (Tipping 2000, personal comm.). Current winter steelhead stocks are considered depressed based on chronically low returns (see Table 18). Spawning escapements were estimated from 1989 through 1992 with a low of 18 in 1989 and a high of 322 in 1992. The stock will likely remain depressed until spawning and rearing habitat in the mainstem improves from the 1980 eruption of Mt. St. Helens (WDF et. al. 1993). There has been no escapement goal set. The mean escapement from 1991 to 1996 for the mainstem North Fork winter steelhead was 185 fish. It is estimated that from 1991 to 1996, none of the run was from hatchery fish (LCSCI 1998). The Toutle River is managed for natural winter steelhead production (WDW 1990).

South Fork Toutle River Winter Steelhead

Historical production estimates are unavailable for this stock. Currently, most winter steelhead spawning occurs in the mainstem. The South Fork Toutle winter steelhead are a mixed of wild production (Tipping 2000, personal comm.). Current winter steelhead stocks are considered healthy (see Table 18). Spawning escapements were estimated from

1984 through 1992 with an average of 1,381, a low of 752 in 1990, and a high of 2,222 in 1988. The escapement goal of 1,058 was exceeded 6 of the 9 years (WDF et. al. 1993). The mean escapement from 1991 to 1996 was estimated to be 893 fish. An estimated 17 percent of the run during these years were hatchery fish (LCSCI 1998).

Table 18: WRIA 26 Winter Steelhead Stock Status

Stock	Screening Criteria	1992 SASSI Stock Status	1997 LCSCI Stock Status	Status (ESA Listing)
Cowlitz	Escapement Trend	Depressed	Depressed	Federal "Threatened"
Coweeman	Escapement Trend	Depressed	Depressed	Federal "Threatened"
Mainstem/N. Fork Toutle	Escapement Trend		Depressed	Federal "Threatened"
South Fork Toutle	Escapement Trend	Depressed	Depressed	Federal "Threatened"
Green	Escapement Trend	Depressed	Depressed	Federal "Threatened"

Adapted from WDF et. al. 1993; Lower Columbia Steelhead Conservation Initiative 1998.

Table 19: WRIA 26 Winter Steelhead Escapement

Stock	Wild Steelhead Escapement Goal	1991-1996 Average Wild Steelhead Escapement	Average % of Wild Escapement Goals	Average % of Hatchery Spawners
Cowlitz	----	----	----	92 %
Coweeman	1,064	351	33 %	27 %
Toutle mainstem and North Fork	----	185	----	0
South Fork Toutle	1,058	893	84 %	17 %[2]
Green River	----	108[1]	----	17 %[2]

1 = Indicates index count, not total.
2 = Hatchery percentage represents overlap of hatchery summer steelhead with wild, winter steelhead.
Adapted from Lower Columbia Steelhead Conservation Initiative, 1998.

Green River Winter Steelhead

Historical production estimates are unavailable for this stock. Currently, the winter steelhead spawning occurs in Devils Creek, and Elk Creek (WDF et. al. 1993). Aside from several small fry plants after the 1980 eruption of Mt. St. Helens, no hatchery winter steelhead have been stocked into the Green River (WDF et. al. 1993), and the river is currently managed for wild production (Tipping 2000, personal comm.). Current winter steelhead stocks are considered depressed based on a short-term severe decline (see Table 18)(LCSCI 1998). Spawning escapements were estimated from 1985 through 1992 (except 1986) with an average of 265, a low of 44 in 1989, and a high of 402 in 1987 (WDF et. al. 1993). There has been no escapement goal set for the Green River. Mean escapement from 1991 to 1996 for the Green River winter steelhead is estimated at 108 fish. It is estimated that from 1991 to 1996, 17 percent of the run was from hatchery fish (LCSCI 1998).

Summer Steelhead (*Oncorhynchus mykiss*)

Historically, few summer steelhead were produced in the Cowlitz River watershed. Very little information is available describing historical abundance and life history of summer steelhead prior to the construction of the Cowlitz Trout Hatchery in 1968 (WDW 1990). From 1962 through 1966, 75 of the 54,044 steelhead counted at the Mayfield Dam upstream fish-passage facility were observed from July to October (Thompson and Rothfus 1969).

Summer steelhead were first introduced into the Green River in 1950, but no adults returned (Lavier 1952). They were introduced into the Coweeman River in 1966 and into the Cowlitz and Toutle rivers in 1968 (WDW 1990). Between 1983 and 1992, the average summer steelhead adult return to Cowlitz River was 4,556, and has ranged from 759 fish in 1983 to 9,019 fish in 1992 (Harza 1999b). The WDFW management objective is to provide a sport harvest in the Cowlitz and Toutle Rivers with 15,000 and 3,000 fish, respectively. WDFW does not address the Cowlitz River summer steelhead stock in the SaSSI report (WDF et. al. 1993); however, for 1980 and 1981, natural fish contributed a mean of 8.7 percent of sampled adults (Tipping 1981 and 1982 as cited in WDW 1990). In the Toutle River, natural fish comprised 6.9 percent of the sampled fish in 1981; however, the number of natural fish present is now estimated at about 50 fish due to the eruption (WDW 1990).

A wooden acclimation structure exists on Brownell Creek, near the mouth of Jordan Creek, where juvenile rearing occurs, mainly for summer steelhead. A total of 30,000 summer steelhead smolts have been annually stocked into the South Fork Toutle River for a popular sport fishery. There are no plans for summer steelhead to be passed over the sediment-retention structure on the North Fork Toutle River (WDW 1990).

Chum Salmon (*Oncorhynchus keta*)

Little data is available on the historical abundance and life history of chum in the Cowlitz River. The Cowlitz River had a total estimated escapement of 1,000 chum in the early 1950s (WDF 1951). An estimated 137,257 chum fry passed the Mayfield Dam site between March and May 1955. Between March and May 1956, an estimated 8,203 chum fry passed the site (Stockley 1961). A run of adult chum was observed 15 miles upstream from the Mayfield dam site prior to any impoundments on the Cowlitz River (Thompson and Rothfus, 1969). Between 1961 and 1966, the Mayfield fish-passage facility only reported collecting two adult chum (Thompson and Rothfus, 1969). Meekin (1961) reported that 12 chum were collected and transported over Mayfield Dam from September 16 through December 22, 1961.

It is probable that spawning occurs on the first available gravel present in the following tributaries; Coweeman and Toutle Rivers, Ostrander, Arkansas, Salmon, Olequa, and Lacamas creeks (WDF 1951). Additionally, WDF (1973) reported chum in Monahan, Delameter, Baxter, and North Fork Arkansas creeks, and the North and South Forks of the Toutle River. Recent WDFW observations report chum salmon in the headwaters of Lacamas Creek (TAG).

Detailed records describing the number of chum captured each year have not been kept, but typically, less than ten adults are collected in an average year at the Cowlitz Salmon Hatchery (Harza 1999c). There are no plans to reintroduce chum to the upper watershed (USFS 1998).

Coastal Cutthroat Trout (*Oncorhynchus clarki clarki*)

Cowlitz River Coastal Cutthroat

In the late 1940s, coastal cutthroat trout were abundant in the Cowlitz River and distributed throughout the watershed (WDF/WGC 1948; Bryant 1949). In 1948, the estimated annual production, based on angler spot-checks in the "upper river", was 49,722 adults. Spawning escapement was estimated to be 24,861 fish. Between 1961 and 1966, adult coastal cutthroat returns to the Mayfield fish passage facility averaged 8,158 fish, ranging from 5,458 fish in 1961 to 12,324 in 1964 (Thompson and Rothfus 1969). Angler-harvest data was not collected or estimated during this period, so actual production from the upper watershed is difficult to estimate. Because of the assumptions involved with this method of estimation, it is likely that these estimates contain a substantial amount of error. Also, these counts do not represent production for tributaries that enter the Cowlitz River below Mayfield Dam (Harza 1997b).

In 1979, hatchery-produced, adult coastal cutthroat returns probably numbered around 11,000 fish (Tipping 1982). Between 1983 and 1992, adults returning to the Cowlitz Trout Hatchery ranged from 766 in 1988 to 6,646 in 1984. There are data to indicate that these hatchery returns were strongly influenced by Columbia and Cowlitz River harvest rates. In 1982 and 1983, Tipping (1986) found that 65.8 percent of tagged hatchery coastal cutthroat trout were harvested in the Cowlitz River, 31.5 percent were harvested in the Columbia River, and 2.7 percent were harvested elsewhere.

The WDFW/Tacoma City Light mitigation agreement states that runs to the Cowlitz are to be 38,600 adult anadromous game fish. The agreement provides that the WDFW shall select the numbers and kinds of species to rear and plant. Currently, the WDFW is managing for 10,000 coastal cutthroat. The agreement stipulates sport harvest and rack returns would both be at 50 percent (WDW 1990). Hatchery returns ranged from 5,471 in 1982 to 480 in 1987, with an average of 2,158 (Tipping 1995). Current hatchery objectives are to maintain the run and provide a recreational fishery, with a mitigation goal of 160,000 smolts per year (Tipping 2000, personal comm.).

The migration peak of wild and hatchery cutthroat occurs in August and September, and the spawning peak of hatchery fish is from November to December, about two weeks earlier than wild fish (Tipping 2000, personal comm.; WDFW 2000).

Currently, the reintroduction plan to the Mayfield/Tilton, Upper Cowlitz, and Cispus subbasins for native (late) winter steelhead, coho, coastal cutthroat are as follows: mark outmigrating juveniles at the Cowlitz Falls Fish Collection Facility and at Mayfield Dam; pass downstream migrants through Mayfield Dam and truck downstream migrants captured at the Cowlitz Falls Fish Collection Facility to below the Barrier Dam; collect marked adult migrants at the Barrier Dam, and truck them above the Cowlitz Falls Dam and into the Tilton River for release (Wolf Dammers 2000, personal comm.). Anadromous cutthroat smolts were first tagged for return to the Tilton and above Cowlitz Falls Dam in 1998 (Tipping 2000, personal comm.)

The present status of the mixed origin hatchery coastal cutthroat trout in the Cowlitz River is somewhat stable (Tipping 2000 personal comm.). After completion of Mayfield and Mossyrock dams, the Cowlitz Trout Hatchery has been used to maintain runs. Hatchery returns averaged 23,454 fish for the 1970s, 2,420 fish for the 1980s, and 2,550 fish for the 1990s (Tipping and Harmon 1999).

However, little is known of the recent status of wild coastal cutthroat trout. A 1979 survey found that an estimated 40% of the 5,014 fish harvested were wild fish (Tipping and Springer 1981). In recent years, anglers could not retain wild cutthroat, impairing estimates of abundance. Most wild fish production is assumed to occur in the Toutle and Coweeman rivers and the habitat-impaired lower river tributaries (Tipping 2000, personal comm.). An average of 337 smolts emigrated from the Mayfield Dam facility in 1998-1999, of which only 2.8% returned to the Barrier Dam as adults (Tipping and Harmon 2000). Additional smolts were captured and transported downstream at the Cowlitz Falls Fish Collection Facility. SaSI Coastal Cutthroat (WDFW 2000) lists the Cowlitz River as depressed based on chronically depressed adult and juvenile trap counts and a long-term decline in Columbia River catch from RM 72 to RM 48 (see Table 20).

Coweeman River Coastal Cutthroat

Data on this stock is limited and no genetic studies have been performed on this stock. Other unknowns are size, age, river-entry times, and spawning times, although it is believed they are similar to other nearby stocks (WDFW 2000).

WDFW (2000) states that Coweeman cutthroat are considered to be native and are sustained by natural production; however it also states that from 1989 to 1993, a yearly average of 12,000 coastal cutthroat smolts from the Beaver Creek Hatchery were released in the Coweeman River. Most recently, releases were reduced to 5,000. Most of these smolts were acclimated at a rearing site below Goble Creek (WDFW 2000). Although spawning time for the hatchery stock has been advanced compared to the native stock, interactions between hatchery and wild cutthroat remain a concern (WDFW 2000). Harvest has only recently been restricted to marked hatchery fish. The status of this stock is depressed, based on a long-term negative trend in the Columbia River catch from RM 48 to 72 (see Table 20). Run-size data is not available for this stock (WDFW 2000).

Toutle River Coastal Cutthroat

Little information is available for historic or present status of coastal cutthroat in the Toutle River. Lavier (1960) reported that 74 fish were captured at the Toutle River Hatchery in 1960. An estimated 40% of the 5,014 cutthroat harvested from the Cowlitz in 1979 were wild fish, many of which probably originated in the Toutle River (Tipping and Springer 1981). No hatchery plants of coastal cutthroat have been made in the Toutle River and none are anticipated (WDW 1990).

All Toutle coastal cutthroat are considered part of one stock (WDFW 2000). Entry into the North Fork Toutle peaks between September and November, with a smaller number of fish moving throughout the winter (WDFW 2000). Spawning time occurs from January to June. Genetic data is unavailable for this stock (WDFW 2000).

The status of the Toutle coastal cutthroat is depressed, based on chronically-low escapement measured at the Toutle River Fish Collection Facility and the North Toutle Hatchery, a long-term negative trend in the Columbia River catch from RM 72 to RM 48, and the habitat destruction from the 1980 eruption of Mt. St. Helens (see Table 20)(WDFW 2000). The stock is showing a slow recovery since 1980, but the escapement is chronically low. Another measure used for stock status is the North Toutle Hatchery count. In 1959, 74 wild coastal cutthroat were captured during coho and chinook collections. After 1991, annual counts have remained below 6 fish (WDFW 2000).

Table 20: WRIA 26 Coastal Cutthroat Stock Status

Stock	Screening Criteria	2000 SaSI Stock Status	Status (ESA Listing)
Cowlitz	Long-Term Negative Trend	Depressed	Proposed for listing as federal “threatened”
Toutle River	Long-Term Negative Trend	Depressed	Proposed for listing as federal “threatened”
Coweeman	Chronically Low, Long-Term Negative Trend	Depressed	Proposed for listing as federal “threatened”

Adapted from WDFW 2000.

Table 21: WRIA 26 Coastal Cutthroat Stocks

Stock	Stock Origin	Production Type
Cowlitz	Native	Wild
Toutle River	Native	Wild
Coweeman	Native	Wild

Adapted from WDFW 2000.

Bull Trout (Salvelinus confluentus)/Dolly Varden (Salvelinus malma)

Fish identified as Dolly Varden, which may actually be bull trout, were supposedly caught for food by Taidmapam, or upper Cowlitz Indians in the upper Cowlitz River watershed (USFS 1997a). There are no recent, official records of these species in the watershed and they are considered to be extinct or to never have existed (USFS 1998).

No bull trout have been reported at the Cowlitz Falls fish-collection facility or at the Mossyrock or Mayfield dams (TAG). It is likely if populations did exist, they would have been found at the Cowlitz Falls Fish Collection Facility, or during on-going electrofishing and stream surveys (TAG).

As of May 2000, the USFWS has not yet made a decision as to whether bull trout exist in the Cowlitz River system.

Pink Salmon (*Oncorhynchus gorbuscha*)

There are few references to pink salmon in the Cowlitz River system. Six pink salmon were trapped and hauled around Mayfield Dam on September 8, 1961 (Meekin 1961). The presence of pink salmon has been noted on a few WDFW survey cards.

HABITAT LIMITING FACTORS BY SUB-BASIN

Introduction

This Limiting Factors Analysis report discusses the major habitat factors limiting salmon production within subbasins of WRIA 26. For each subbasin, the report examines the condition of a number of habitat variables including; access problems, floodplain connectivity, streambed sediment conditions, in-channel and riparian conditions, water quantity and quality, and biological processes. Habitat conditions were assessed using a combination of existing data from published and unpublished sources, as well as the professional opinion of members of WRIA 26 Technical Advisory Group (TAG). The following summary provides the reader with some background on each of these habitat variables and explains how each variable may be altered by land use activities and/or patterns.

Categories of Habitat Limiting Factors:

Loss of Access to Spawning and Rearing Habitat

This category includes culverts, tide gates, levees, dams, and other artificial structures that restrict access to spawning habitat for adult salmonids or rearing habitat for juveniles. Additional factors considered are low stream flow or temperature conditions that function as barriers during certain times of the year.

Information from the TAG, a number of culvert surveys, and variety of published documents was used to identify barriers to passage and to develop the Barriers Maps (Maps 3a and 3b) in Appendix A.

Floodplain Conditions

Floodplains are relatively flat areas adjacent to larger streams and rivers that are periodically inundated during high flows. In a natural state, they allow for the lateral movement of the main channel and provide storage for floodwaters, sediment, and large woody debris. Floodplains generally contain numerous sloughs, side channels, and other features that provide important spawning habitat, rearing habitat, and refugia during high flows. This category includes direct loss of aquatic habitat from human activities in floodplains (such as filling) and disconnection of main channels from floodplains with dikes, levees, and revetments. Disconnection can also result from channel incision caused by changes in hydrology or sediment inputs.

Information from the TAG, Lewis County, Cowlitz Conservation District, and a number of published sources was used to develop the Stream Floodplain Connections maps (Maps 10a and 10b) in Appendix A. This map is not a complete inventory of all areas where streams have been disconnected from their floodplains, only those that have been identified to date.

Streambed Sediment Conditions

Changes in the inputs of fine and coarse sediment to stream channels can have a broad range of effects on salmonid habitat. Increases in coarse sediment can create channel instability and reduce the frequency and volume of pools, while decreases can limit the availability of spawning gravel. Increases in fine sediment can fill in pools, decrease the survival rate of eggs deposited in the gravel, and lower the production of benthic invertebrates. This category addresses these and other sediment-related habitat impacts caused by human activities throughout a watershed. These impacts include increases in sediment input from landslides, roads, agricultural practices, construction activities, and bank erosion; decreases in gravel availability caused by dams and floodplain constrictions; and changes in sediment transport brought about by altered hydrology and reduction of large woody debris.

Channel Conditions

This category addresses instream habitat characteristics that are not adequately captured by another category, such as bank stability, pools, and large woody debris. Changes in these characteristics are often symptoms of impacts elsewhere in the watershed, which should also be identified in the appropriate category (sediment, riparian, etc.).

Riparian Conditions

Riparian areas include the land adjacent to streams, rivers, and nearshore environments that interacts with the aquatic environment. This category addresses factors that limit the ability of native riparian vegetation to provide shade, nutrients, bank stability, and a source for large woody debris. Human impacts to riparian function include timber harvest, clearing for agriculture or development, construction of roads, dikes, or other structures, and direct access of livestock to stream channels.

Riparian conditions within WRIA 26 were mapped within 30-meter buffers along all anadromous and DNR Typed 1, 2, and 3 streams in WRIA 26. Forest cover GIS data developed from 1988 Landsat 5 Thematic Mapper (TM) data, that was updated with 1991 and 1993 TM data, was used to determine riparian cover (Lunetta et. al. 1997). Forest cover was broadly categorized into four forest classes based on forest type and age class (see Table 3 in Watershed Characterization). The overall thematic accuracy of the 1988 TM-based land-cover categorization was 92 percent (PMR 1993 as cited in Lunetta et. al. 1997). The non-forest land cover and most surface water features were derived from 1:250,000-scale U.S. Geological Survey land-cover/land-use data. For more information how this data was collected and used (see Lunetta et. al. 1997).

Riparian buffers were rated as good, poor, or unknown, depending upon the type of forest cover category within the 30-meter buffer. Buffers with early-seral stage forest cover were rated as unknown because of its wide range of coniferous crown cover (from 10 to 70% coniferous crown cover). Also, when a riparian assessment using this data in the Skagit basin was ground-truthed, 88% of the early seral category was found to be a "functioning" riparian area (Tom Loranger 2000, personal comm.). Buffers with late- and mid-seral stage forest cover were mapped as "good" riparian habitat and other lands and non-forested lands were mapped as "poor" habitat (see Table 3 in Watershed Conditions for land cover descriptions). This course scale analysis of riparian conditions provides the best picture available of riparian conditions at the watershed scale, but should not be used to identify specific locations for riparian restoration without verification of existing site conditions.

Water Quality

Water quality factors addressed by this category include stream temperature, dissolved oxygen, and toxics that directly affect salmonid production. Turbidity is also included, although the sources of sediment problems are addressed in the streambed sediment category. In some cases, fecal coliform problems are identified because they may serve as indicators of other impacts in a watershed, such as direct animal access to streams.

Water Quantity

Changes in flow conditions can have a variety of effects on salmonid habitat. Decreased low flows can reduce the availability of summer rearing habitat and contribute to temperature and access problems, while increased peak flows can scour or fill spawning nests. Other alterations to seasonal hydrology can strand fish or limit the availability of habitat at various life stages. All types of hydrologic changes can alter channel and floodplain complexity. This category addresses changes in flow conditions brought about by water withdrawals, the presence of roads and impervious surfaces, the operation of dams and diversions, alteration of floodplains and wetlands, and a variety of land use practices.

Estuarine and Nearshore Habitat

This category addresses habitat impacts that are unique to estuarine and nearshore environments. Estuarine habitat includes areas in and around the mouths of streams extending throughout the area of tidal influence on fresh water. These areas provide especially important rearing habitat and an opportunity for transition between fresh and salt water. Human impacts to these areas include loss of habitat complexity due to filling, dikes, and channelization; and loss of tidal connectivity caused by tidegates. Nearshore habitat includes intertidal and shallow subtidal salt water areas adjacent to land that provide transportation and rearing habitat for adult and juvenile fish. Important features of these areas include eelgrass, kelp beds, cover, large woody debris, and the availability of prey species. Impacts include bulkheads, over-water structures, filling, dredging, and alteration of longshore sediment processes.

The Conservation Commission is only assessing habitat limiting factors within tributaries to the Columbia River, and we will not be addressing habitat issues within the Columbia itself. Therefore, an assessment of estuarine and nearshore habitat is not included in this report.

Lake Habitat

Lakes can provide important spawning and rearing for salmonids. This category includes human impacts that are unique to lake environments, such as the construction of docks and piers, increases in aquatic vegetation, and the application of herbicides to control plant growth.

Lake habitat was not addressed specifically within this report, but was addressed where it applied to specific habitat limiting factors such as water quality, passage, and water quantity. The reservoirs behind the dams form most of the lake habitat within WRIA 26.

Biological Processes

This category addresses impacts to fish brought about by the introduction of exotic plants and animals and also from the loss of ocean-derived nutrients caused by a reduction in the amount of available salmon carcasses.

WRIA 26 was divided into seven sub-basins for discussion of the habitat limiting factors:

- Coweeman River Subbasin
- Lower Cowlitz Subbasin
- Toutle River Subbasin
- Mayfield/Tilton Subbasin
- Riffe Lake Subbasin
- Cispus River Subbasin
- Upper Cowlitz Subbasin

(see Map 4 in Appendix A for basin boundaries).

Coweeman River Subbasin

The Coweeman River subbasin includes the lower Cowlitz mainstem to the Toutle River (RM 20) and its left bank tributaries including the Coweeman River watershed, Ostrander Creek, Salmon Creek (in Cowlitz County), and other smaller tributaries (see Map 4).

In general, there was little information available for habitat conditions within the lower reaches of the Coweeman and its tributaries, and for the smaller tributaries to the Cowlitz. Most of the habitat ratings came from the collective experience of TAG members. Weyerhaeuser (1996) conducted a Watershed Analysis for the upper Coweeman subbasin (above RM 17) that provides a significant amount of information on habitat conditions of the upper watershed.

Access

Historically, there were a number of splash dams in the Coweeman subbasin that blocked access to habitat (WDF 1951; WDW 1990). In 1951, WDF noted that the subbasin was underescaped due to splash dams blocking habitat. There is still a remnant splash dam on upper Baird Creek (Weyerhaeuser 1996).

Information on culverts and other artificial barriers to fish passage was gathered from both the personal experience of TAG members and from a variety of other documents. Information on fish passage barriers is generally limited within the subbasin. The Cowlitz Conservation District is conducting culvert inventories in the Coweeman subbasin on both public and private roads. The surveys should significantly increase our understanding of passage problems. The survey will follow WDFW protocols, with completion expected in the year 2000. Map 3a in Appendix A shows known and potential passage barriers within the subbasin.

Known or potential passage problems within the Coweeman subbasin include:

- A long culvert under I-5 on Pin Creek is considered a partial barrier (TAG);
- An unknown right-bank tributary to the Coweeman at RM 5.15 has a blocking culvert at the Allen Street crossing (TAG);
- Approximately 70% of the anadromous habitat in Turner Creek (RM 9.4) is at least partially blocked by an undersized culvert at Rose Valley Road. There are several additional blockages on private roads upstream of this culvert that need assessment (TAG);
- Nye Creek (RM 10.4) has a blocking culvert at Rose Valley Road. This is a minor anadromous stream;
- An unnamed stream on the right bank of Goble Creek (approximately 1.5 miles upstream from the North Fork Goble intersection) has a blocking culvert. This small stream appears to be fairly steep and data needs to be collected on upstream habitat;
- Three small unnamed streams between Goble and Mulholland creeks have blocking culverts that need assessment;
- A Mulholland Creek tributary has a culvert under the 1732 Road (T8N R1E Sec.9SW) with a 60cm drop that potentially impacts anadromous fish (Weyerhaeuser 1996).
- An unnamed right-bank tributary to the Coweeman (Stream #0114) has a culvert under the 1680 Road (T8N R2E Sec. 23SW) that needs further assessment. It was unplugged in 1995, but its status is now unknown (Weyerhaeuser 1996).
- Upper Baird Creek has a remnant splash dam that is approximately 8m high. It is not known to what extent this remnant dam affects fish passage (Weyerhaeuser 1996).
- Unnamed creeks (Stream Index #0128, 0129, 0186, and 0188) all have blocking culverts either at their mouths and/or where long culverts pass under I-5;
- Ostrander Creek has a box culvert just upstream of the confluence with the South Fork Ostrander Creek (approximately RM 1) that is considered a partial barrier and may block fall chinook passage;
- A small unnamed right bank tributary to South Fork Ostrander Creek has a blocking culvert near the end of anadromous habitat.

Major natural barriers within the upper Coweeman subbasin that limit anadromous distribution occur in mid-Mulholland Creek and in the upper Coweeman headwaters near RM 32 (Weyerhaeuser 1996). Sea run cutthroat distribution may be limited by a cascade near RM 24 on the Coweeman just above the confluence with Brown Creek. Table 22 lists natural passage barriers in the upper Coweeman subbasin.

Table 22: Natural Barriers in the Coweeman Subbasin

Stream	River Mile	Barrier Type	Estimated Height	Influence of Fishery
Mulholland	4.3	Cascade/Fall	5 meters	Impassable to all species
Mulholland	1.7	Fall/Cascade	2 meters	Steelhead hindrance and possible coho barrier
Little Baird	1.5	Cascade	7 meters	Impassable to all species
Mainstem	23.3	Falls	2 meter	Chinook limit
Mainstem	28.5	Cascade	1m drop/5m long	Steelhead hindrance and possible coho barrier
Mainstem	31.3	Washboard Falls	---------	Likely coho barrier
Mainstem	31.6	Falls	2 meter	Hindrance to steelhead

Adapted from Weyerhaeuser 1996

Floodplain Connectivity

TAG members rated floodplain connectivity as poor within the lower 20 miles of the Cowlitz mainstem. Only the Sandy Bend area near Castle Rock has any connected floodplain habitat (see Map 10a in Appendix A). The balance of the lower Cowlitz is contained within dikes, riprap, and/or deposited dredge spoils from the eruption of Mt. Saint Helens, eliminating almost all floodplain habitat.

The construction of I-5 disconnected many of the smaller tributaries from their historic floodplains. Pin Creek has good floodplain connectivity above I-5. The recent purchase of a residence in the lower floodplain of Ostrander Creek should prevent further restriction of its floodplain habitat, and provide some restoration potential. Salmon Creek has been channelized in the lower reaches below the railroad tracks by placement of dredge spoils adjacent to the creek. The TAG noted that above the road and railroad tracks floodplain habitat along Salmon Creek was in good condition.

The lower four miles of the Coweeman River is a low-gradient stream that is tidally influenced. Historically, the floodplain likely meandered through a large floodplain that would have included critical rearing and over-wintering for juveniles. With the development of Kelso’s industrial and commercial areas and I-5, the lower four miles of the river has been channelized and diked so that almost all of the lower floodplain has been disconnected from the river (TAG). Only a small remnant area of floodplain sloughs and off-channel habitat remains below RM 1 to the east of the river and adjacent to I-5.

Above RM 4 to RM 7.5 the Coweeman channel is fairly unconstrained. The upper mile or two of this segment contains some good potential for restoration projects because of its unconfined channel, wetland habitats, and abandoned oxbows (TAG). There are some open-water ponds adjacent to the river in this reach that appear to be old gravel pits. If a connection to the river is provided, these abandoned gravel pits have the possibility of adding to limited over-wintering habitat within the basin. The channel is largely confined within a canyon with moderate gradients for the next 11 miles (Bryant 1949).

Further upstream the valley becomes even narrower and the gradient increases as well. Above RM 17, few reaches in the mainstem Coweeman channel are unconfined. Of the few reaches that flow through ancient terraces of alluvial deposits, most are incised and disconnected from the floodplain terraces. Even during the 1996 floods, the channel did not encroach significantly onto these terraces (Weyerhaeuser 1996).

Bank Stability

Bank stability along most of the lower 20 miles of the Cowlitz mainstem is generally good because the banks are mostly diked and/or filled. However, there are some unstable areas where dredge spoils are actively eroding. USFWS (1984) states that the lower Cowlitz is very unstable laterally, and that bank erosion, especially around the Horseshoe Bend area, is creating some serious problems. TAG members generally considered bank stability as good for most of the smaller tributaries to the Cowlitz. Pin Creek has some active slides in the upper reaches, and Ostrander Creek has some bank armoring in the residential areas.

Bank stability along the lower 4 miles of the Coweeman was considered good because it too has been almost completely diked. Above RM 4, agriculture is the dominant land use for the next 4 miles and bank stability along the mainstem Coweeman was considered "poor" by the TAG. Above RM 7.5 the mainstem flows through a narrow valley with bedrock and with generally good bank stability (TAG).

Overall, TAG members rated bank stability within both Turner and Goble Creeks as good. However, one TAG member noted some stability problems within the upper reaches of Goble Creek. Timber harvest within riparian areas has likely contributed to this instability.

From approximately RM 17 to RM 26 the parent material within the Coweeman watershed is weak, and removal of lateral support, often by the stream channel, results in frequent small mass failures and bank erosion. This results in local high sediment delivery to steam channels (Weyerhaeuser 1996).

Numerous debris torrents have occurred in the Coweeman headwaters above the confluence with O'Neil Creek (~RM 30)(Weyerhaeuser 1996). These torrents occurred in response to certain types of road construction and often scoured and widened the entire channel in which they occurred (Weyerhaeuser 1996). Rain-on-snow events associated with the 1996 floods resulted in numerous debris flows in the upper Coweeman watershed. Scouring and widening of the channels occurred in portions of Baird Creek, Mulholland Creek, Nineteen Creek, and in portions of the mainstem Coweeman

(Weyerhaeuser 1996). Preliminary investigations found that most of the debris flows were road related (Weyerhaeuser 1996).

Large Woody Debris

LWD is generally poor throughout the subbasin. Extensive splash damming occurred in the early part of the century (Bryant 1949; Weyerhaeuser 1996). LWD was either actively removed from many of the stream channels and/or scoured from the channel when the stored logs were released (Weyerhaeuser 1996). The Cowlitz mainstem contains only minor amounts of LWD on the margins and banks, but considering the size of the channel and the flow, the channel may never have contained significant amounts of stable LWD. All the minor tributaries to the lower Cowlitz within this subbasin have generally poor LWD levels, as does the Coweeman and its tributaries (TAG; Weyerhaeuser 1996).

The Upper Coweeman Watershed Analysis (Weyerhaeuser 1996) evaluated riparian conditions to determine LWD recruitment potential within a number of subbasins of the upper watershed. Riparian areas that contained mature coniferous and mixed stands were classified as having high near-term recruitment potential; areas with mature deciduous stands were classified as having moderate near-term recruitment potential; and areas with all young stands had low near-term recruitment potential. For the entire upper basin, approximately half of the surveyed streams had high near-term recruitment potential, and approximately one-third had low near-term recruitment potential (Weyerhaeuser 1996).

For the entire Coweeman Subbasin, only 10.3 percent of the riparian habitat contains >70% mature coniferous cover (see Table 23). Without mature conifers, long-term LWD recruitment potential is limited for many stream systems within the subbasin.

Pool Frequency

There was generally very little information of the quantity or quality of pool habitat within the subbasin. Most of the lower Cowlitz River within this subbasin is tidally influenced (to approximately RM 17), and large percentage of the area is low gradient pool habitat. The lower Coweeman River is also tidally influenced (to ~RM 4) with a high percentage of the area in pool habitat. However, the pool habitat within the lower Cowlitz and Coweeman Rivers has very little cover and habitat diversity, as the rivers are generally diked, channelized, and simplified.

Where TAG members were familiar with pool frequencies in tributaries to the Cowlitz, they generally considered them poor. Ostrander Creek, which the TAG rated as fair, was the only exception to the poor ratings for pool frequencies of the Cowlitz River tributaries in this subbasin. Pool habitat within the mainstem Coweeman was considered good between RM 4 - RM 7.5 (TAG). However, the area contains what may be more glide habitat than true pool habitat. In the reach between RM 7.5 and 18.4, pool habitat is largely controlled by bedrock and is probably similar to historic conditions. Turner and Goble Creeks have generally fair pool habitat (TAG).

The Upper Coweeman Watershed Analysis (Weyerhaeuser 1996) lists low pool frequencies and depths as a major concern for fish habitat within most areas of the upper Coweeman watershed. LWD is important for pool formation within most of the upper watershed, and it is generally lacking throughout this area (Weyerhaeuser 1996).

Side Channel Availability

There are very few reaches within any of the lower Cowlitz or Coweeman River that have connection to any side-channel habitat (TAG; Weyerhaeuser 1996). Diking and the placement of dredge spoils from the eruption of Mt. Saint Helens have eliminated almost all side channel habitat in these systems.

Between RM 4 to RM 7.5, the Coweeman River channel is fairly unconstrained. The upper mile or two of this segment contains some good potential for restoration projects because of its unconfined channel, wetland habitats, and abandoned oxbows (TAG). There are some open-water ponds adjacent to the river in this reach that appear to be old gravel pits that could potentially provide off-channel rearing habitat for juveniles (TAG). Most of the rest of the Coweeman River is constrained within an incised or bedrock controlled channel (Weyerhaeuser 1996).

Data on side-channel habitat is limited for most of the other Cowlitz River tributaries. Placement of dredge spoils along the lower end of Salmon Creek has effectively channelized the stream. Interstate-5 and development in the lower reaches has reduced connection to side-channels in Ostrander Creek. The railroad also runs adjacent to Ostrander Creek for almost 4 miles, eliminating connection to any historic side-channel habitat or the development of any new habitat.

Substrate Fines

Fine sediments are the dominant substrate within the tidally-influenced, low-gradient reaches of the Cowlitz River, the Coweeman River, and Ostrander and Salmon creeks. These lower reaches likely always contained a high proportion of fine sediments. The eruption of Mt. Saint Helens added huge quantities of fine sediments to these reaches and to their floodplains (Cowlitz County 1983; Lisle et. al. 1982; Collins and Dunne 1981).

The gentle relief of the Coweeman watershed from approximately RM 17 to RM 26 is largely the result of the deeply weathered tuffaceous parent material interbedded with more resistant tuffs. This tuffaceous material has led to a high background sediment delivery rate because much of the soils and regolith have a high fraction of fine material (up to 90%)(Weyerhaeuser 1996). The fine sediment is apparent in the channels as a chocolate brown stormflow and fine sediment accumulation on channel margins, in backwater areas, and in side channels (Weyerhaeuser 1996). Because the parent material is weak, removal of lateral support, often by the stream channel, results in frequent small mass failures and bank erosion. This results in local high sediment delivery to steam channels (Weyerhaeuser 1996).

Historically, logging and splash damming have contributed to fine sediment loading within the subbasin (Weyerhaeuser 1996). Splash damming captured and stored sediments. After the complete removal of these dams, the channels incised through these deposits creating terraces with vertical banks that can be a chronic low-volume sediment source (Weyerhaeuser 1996). Splash dams were located on Sam Smith Creek, Mulholland Creek, Baird Creek, Hill Creek and two were located on the upper mainstem Coweeman (one just below and one just above Baird Creek)(Weyerhaeuser 1996). Skid roading in the early part of the century also led to significant sediment removal from the hillslopes, with a significant proportion of this sediment likely reaching the stream channels (Weyerhaeuser 1996).

WDW (1990) noted that sedimentation and gravel quality are habitat constraints on the production of coastal cutthroat, winter steelhead, fall chinook, and coho within the Coweeman subbasin. In the LFA habitat rating standards, road densities are used as a surrogate to measure excessive fine sediment inputs to stream systems (see Salmonid Habitat Condition Rating Standards in Appendix B). Using the LFA standards, road densities above 3.0 miles/square mile likely increase fine sediment inputs to the point that substrates have unacceptable levels of fines. With road densities of 6.54 miles of road/square mile and over 69 miles of stream adjacent roads within the subbasin (Lewis County GIS 2000), fine sediment delivery to stream channels likely continues to be a significant problem in the subbasin.

The Upper Coweeman Watershed Analysis (Weyerhaeuser 1996) identified three roads that contribute substantial amounts of fine sediment to stream systems within the upper watershed. The Rose Valley Road is a primary road that experiences heavy traffic and is only one lane wide. Alone, it contributes an estimated 351 metric tons/year to adjacent stream systems, or 11% of the total estimated input of fine sediment from roads in the upper watershed (Weyerhaeuser 1996). The 1600 Road and 1680 Road contribute 94 and 50 metric tons/year respectively (Weyerhaeuser 1996).

The upper Coweeman mainstem and the mainstems of Mullholland and Baird creeks are fairly confined channels with high stream power. Therefore, there are few areas that store sediments, coarse or fine (Weyerhaeuser 1996).

Riparian Conditions

Riparian conditions are generally poor throughout the Coweeman subbasin. Along the lower reaches of the Cowlitz and Coweeman rivers extensive diking, fill placement, and development have significantly impacted riparian buffer size and riparian vegetation. Agricultural activities and forest practices have also reduced and/or eliminated riparian vegetation in this subbasin. Within the subbasin there are over 69 miles of valley bottom roads that reduce or eliminate riparian function. The railroad runs adjacent to Ostrander for almost 4 miles, reducing riparian buffer size and function.

Map 11a in Appendix A displays generalized riparian conditions within a 30-meter buffer throughout WRIA 26. The forest cover data, from which this map was originally derived, came from 1988 Landsat 5 Thematic Mapper (TM) data and was updated with 1991 and 1993 TM data (Lunetta et. al. 1997). Only a very limited amount (10.3%) of the riparian habitat in the Coweeman subbasin is in “good” condition, and the majority of good riparian habitat occurs above the anadromous zone on the Coweeman River (see Table 23). Early-seral stage vegetation (unknown category) covers 58.5 percent of riparian habitat, and 31.2 percent of riparian habitat falls in the “poor” category. Map 11a also illustrates how poor the riparian conditions are along much of the lower Cowlitz and Coweeman Rivers, and Ostrander Creek.

Table 23: Riparian Condition Summary for Coweeman Subbasin

Subbasin Name	Riparian Condition	Stream Miles	Percentage
Coweeman	Good	39.21	10.3
	Unknown	223.27	58.5
	Poor	118.99	31.2
Totals		*381.47*	*100.0*

Lunetta et. al. 1997; Lewis County GIS 2000

Water Quality

In accordance with Section 303(d) of the federal Clean Water Act, every two years each state must identify its polluted waterbodies and submit this list to EPA. These are *water quality limited* estuaries, lakes, and streams that fall short of state surface water quality standards, and are not expected to improve within the next two years. These standards are the criteria to ensure our waters can be beneficially used for purposes we all enjoy, from fishing, swimming, boating, and drinking to industrial and agricultural purposes, and fish habitat (WDOE 2000).

The lower Cowlitz River at RM 4.9 was placed on the 303d list in 1996 for excursions beyond the criteria set for pH, water temperature, and fecal coliform (WDOE 1998). None of these parameters are now included on the 1998 303d list, because the available information does not meet the Water Quality Program policy for listing this segment for this parameter or the segment now meets water quality standards (WDOE 1998). However, the lower Cowlitz was placed on the 1998 303d list for 3 excursions beyond the National Toxic Rule criterion out of three samples for levels of arsenic.

Water temperature was monitored within the Coweeman River near Kelso by the USGS from 1950 to 1967. This data was complied and summarized by Higgins and Hill (1973). Temperatures ranged from 0.0°C to 27.8°C at RM 7.5 in the Coweeman (Harza 1999a). All July and August maximum water temperatures, most June and September maximum temperatures, and about of third of the May maximum temperatures measured over that time period exceeded 18°C (Harza 1999a). Many of the July and August temperatures exceeded 25°C (Harza 1999a). The Coweeman River was also classified as “temperature sensitive” due to intensive logging (Nunamaker 1986 as cited in WDW 1990). Nunamaker (1986) noted that summer daily ambient water temperatures exceeded 60° F (15.6 °C) for a seven-day period.

Water temperatures within the Coweeman continue to exceed state water quality standards. The Coweeman River was listed on the Washington Department of Ecology's 1996 (WDOE 1998) 303d list for water quality excursions beyond state standards for pH, DO (dissolved oxygen), and temperature. The 303d listing for pH and DO were removed from the 1998 list because the available information did not meet the Water Quality Program policy for listing; however, the Coweeman remains on the 1998 303d list for numerous water temperature excursions beyond state standards near RM 2.5 and 9.5 (WDOE 1998).

Tributaries to the Coweeman also included on the 1998 303d list included:

- Baird Creek for water temperature exceedances;
- Mulholland Creek for water temperature exceedances;
- Goble Creek for water temperature exceedances.

Water Quantity

The Coweeman River originates from foothills below 3,000 feet and is rated as poor in summer water yield (USSCS 1974). Low flows have occasionally impeded migrations of fall chinook and coho in the Coweeman subbasin. WDW (1990) lists low flows as a habitat constraint within the Coweeman subbasin, because low flows reduce juvenile salmonid production by limiting summer rearing habitat. While low flows may be a problem within the Coweeman, according to the Caldwell (1999) it has relatively better summer rearing flows than most rivers and creeks in the lower Columbia area.

Toe width flows (a way of developing relationships between stream flows and fish habitat requirements; see Caldwell et. al 1999) were calculated for the Coweeman River, and Ostrander Creek. A hydrograph is available for the Coweeman River with a 34-year period of record. Median-flows in the Coweeman River hover near 600 cubic feet per second (c.f.s.) in the wintertime and drop down to near 50 c.f.s. in the July through September period (Caldwell 1999). Spot flow measurements were taken for Ostrander Creek in late August, early October, and November of 1998.

In comparing the optimal toe width flows of Table 24 with the spot flow measurements taken in the late summer and fall of 1998, it appears that fall spawning flows in the Coweeman are less than optimal for salmon until November when optimal levels are approached for all species present. Steelhead and salmon rearing flows are about 20 cfs less than optimal rearing flows of 70-76 cfs in the mid July through September period. Flow measurements for the Coweeman Rivers and Ostrander Creek are listed in Table 25.

In comparing the optimal toe width flows of Table 24 with the spot flow measurements taken in the late summer and fall of 1998, it is apparent that Ostrander Creek had flow levels on August 31, and October 3 that are far below optimal for spawning and rearing conditions. By November 10, the creek still had too little water to be anywhere near optimal flows for spawning but flows are approaching optimal levels for juvenile salmonid and steelhead rearing (Caldwell 1999).

Table 24: Toe-Width Flows for Coweeman Subbasin

Stream Name	**Tributary to**	**Average Toe Width (in feet)**	**Toe-Width Flow for Fish Spawning and Rearing (in cfs)**					
			Chinook Spawning	Coho Spawning	Chum Spawning	Steelhead Spawning	Steelhead Rearing	Salmon Rearing
Coweeman River (@ Rose Valley Rd Crossing))	Cowlitz River	75.5	289.9	158.7	289.9	233.7	76.1	70.3
Ostrander Creek (@ Ostrander Rd**)**	Cowlitz River	33	103.9	53.7	103.9	89.5	23.5	21.4

Table 25: Coweeman Subbasin Measured Flows (in cfs)

Date	10/1/97	11/1/97	12/1/97	1/1/98	3/1/98	7/1/98
Coweeman River @ Rose Valley Rd Crossing)	121.5	874.1	275.2	713.8	398.3	52.2
Date	8/31/98	10/1/98	11/10/98			
Ostrander Creek (@ Ostrander Rd)	3.2	2.4	16.6			

Caldwell et. al. 1999

Biological Processes:

The Conservation Commission is using the number of stocks meeting escapement goals as a surrogate measurement of nutrient levels within stream systems (see Appendix B). Escapement for most anadromous stocks in the Coweeman is well below historic averages (WDF et. al. 1993: LCSCI 1998), and the lack of carcasses contributing nutrients to the systems may be limiting production within the subbasin. The escapement goal is 1,064 winter steelhead in the Coweeman River. This goal was reached in 1987, but in recent years estimated escapements are down to about 400 fish (LCSCI 1998). The Coweeman River coho stock status is also depressed based on escapement trend. Natural spawning is presumed to be quite low and subsequent juvenile production is below stream potential. In 1951, WDF estimated that 1,000 chum spawned in the first available gravel in a number of the lower tributaries including the Coweeman River, and Salmon and Ostrander creeks (WDF 1951). Few, if any chum return to these systems today. Only Coweeman River fall chinook stocks are considered healthy based on escapement trends (WDF et. al. 1993). Even with fall chinook stocks, the average return since 1988 has been 588 fish compared to an estimated return of 5,000 fish in 1951 (WDF et. al. 1993.)

Toutle River Subbasin

The Toutle River subbasin includes the Toutle River and its major tributaries, the North and South Forks of the Toutle, the Green River, and the Silver Lake basin (see Map 4).

In general, there was a considerable amount of data on the Toutle River system from studies on the effects of the eruption of Mount St. Helens. The Forest Service also assessed habitat conditions in the upper Toutle River watershed. However, habitat conditions have changed rapidly within streams affected by mud and debris flows from the eruption, and data on habitat conditions within the last five years is generally lacking.

Access

Passage barriers were mapped for the Toutle subbasin on Map 3a in Appendix A. There are two major obstacles affecting fish passage within the Toutle subbasin: the fish collection facility for the Sediment Retention Structure (SRS) on the North Fork Toutle and the Silver Lake Dam at the head of Outlet Creek. There have been large problems operating the fish collection facility below the SRS due to the heavy sediment loads in the North Fork. The trap can't be operated when high sediment loads are flushed over the SRD. Care has to be taken when operating the water intakes systems for the fish collection facility to allow sufficient attractant flows to successfully operate the trap, yet, minimize sediment accumulation (Loch and Downing 1990). This occurs most often in the fall, and at times during the peak of coho, steelhead, and cutthroat trout runs (TAG). Returns of cutthroat trout in 1998-1999 fell sharply after the trap could only be operated for 1-2 hour stretches before plugging because of the heavy sediment loads during the peak of the cutthroat migration (TAG).

Depending on flow conditions and how the lake level control dam is operated, adult salmon and steelhead entering the Silver Lake basin to spawn during the fall and winter months may be delayed or blocked from accessing the lake's tributaries (Weyerhaeuser 1994). No water was flowing over the dam during low summer flows in 1992. The absence of attracting flows in Outlet Creek, elevated stream temperatures due to low flows, and inadequate flows to operate the fish ladder may all limit passage at times into the Silver Lake system (TAG; Weyerhaeuser 1994).

Other blockages that were identified within the Toutle subbasin included:

- Sucker Creek: the railroad crossing and several beaver dams may limit upstream passage (Weyerhaeuser 1994).
- Hemlock Creek: a culvert under the Weyerhaeuser railroad crossing on lower Hemlock Creek is a concern due to its length and because a trash rack often collects enough debris to block passage (Weyerhaeuser 1994). A 20-foot falls blocks passage 1-mile upstream from this blockage (CCD 1994; Weyerhaeuser 1994).

- North Fork Wyant Creek: a culvert blocks passage at the 4531 Road crossing (Repair was considered a high priority by the TAG because this is a good coho stream).
- Studebaker Creek: Three partially blocking box culverts under the railroad crossing with sheet flow should be assessed. However, chinook and coho adults do get past this barrier and there is blocking culvert up higher in the system.
- Johnson Creek: open to a blocking culvert up high in the system on the 4210 Rd.
- Alder Creek: possible low flow barrier near mouth because the channel is aggraded without a defined channel (TAG).
- Eighteen Creek: a culvert under the 1890 Road may be a passage barrier and it needs assessment (TAG).
- Green River: the fish weirs at the Toutle River Hatchery generally prevent volitional passage upstream (TAG).
- Jim Creek: TAG members identified the culvert under the 519 Road as a passage barrier.

The Cowlitz County Conservation District, partnering with Weyerhaeuser Company, is conducting a culvert survey throughout the Toutle Subbasin according to WDFW protocol (outside the National Monument boundary). The Survey is scheduled to be complete by the fall of 2000.

Floodplain Connectivity

Floodplain habitat within the Toutle River Subbasin was heavily impacted by the eruption of Mt. Saint Helens. Mudflows and tephra deposits filled many of the river valleys within the subbasin and flood capacity was significantly reduced. Within one year after the eruption of Mt. Saint Helens, over 20 million cubic yards of sediment had been dredged from the river and placed mainly within the floodplain and adjacent wetlands (Cowlitz County 1983). The lower Toutle River now meanders through a wide shallow valley with an aggraded channel and dredge spoils essentially forming dikes along its banks.

Floodplain connectivity has also been affected along a number of tributaries within the subbasin including:

- The lower 3.5 miles of the South Fork Toutle has been dredged with spoils placed in the floodplain’s wetlands (TAG). From the 4735 Bridge (RM 5.7) to the railroad bridge (RM 2.5) on the South Fork, riprap has been placed along most of the banks.
- The lower end of Johnson Creek is incised, reducing floodplain connectivity.
- Floodplain connectivity is also generally poor below the sediment retention structure (RM 12.6) on the North Fork Toutle. The channel has been dredged, diked, and riprapped in areas (TAG).
- Above the SRD, the North Fork channel is largely unconfined and floodplain connectivity is generally good (TAG).

- From the hatchery area on the Green Fork to approximately 1/3 of a mile downstream, the channel is diked (TAG).
- Outlet Creek is channelized along the lower 6,000 feet with significant amounts of diking (Weyerhaeuser 1994).

Bank Stability

The eruption of Mt. Saint Helens has substantially impacted bank stability within the Toutle River subbasin. The almost complete denudation of the watershed combined with extensive pre- and post-eruption logging has left the basin hydrologically immature and subject to increased peak flows which cause bank and bed scour and channel shifting (WDF et. al. 1993). Mud and debris flows in the North and South forks of the Toutle River were severe enough to change the channel type from a meandering single "C" type channel with some braiding to a braided "D" type channel (USFS 1997c). In other streams, debris washouts scoured channels to bedrock. Lower reaches of many tributaries were covered by mud and debris flows, which obliterated old channels and forced streams to form new courses (USFWS 1984). The North Fork Toutle River, and the lower reaches of Hoffstadt, Bear, Maratta, Elk, Castle, Jackson, and Coldwater creeks are examples of streams that were buried and are seeking new channels across the avalanche (USFWS 1984). All of the affected streams are unstable with shifting, braided stream channels that frequently change course during storm runoff (USFWS 1984). Channel migration has resulted in extensive bank erosion within the lower Toutle River system also (Cowlitz County 1983). The placement of unconsolidated dredge spoils on the margins of the lower river channel has further increased bank instability in areas (TAG).

Very little information has been collected on the conditions of stream channels since early- to mid-1980. Many of the stream systems are in the process of recovering from the affects of the eruption. New channels have been cut across the mud and debris flows and pool and riffle habitat has formed in many areas (USFWS 1984; Jones and Salo 1986). Surveys of Herrington Creek show a marked increase in channel development since 1981, and in 1984 it appeared to have a fundamentally stable channel (Jones and Salo 1986). However, the South and North forks of the Toutle are still highly unstable, as the channel migrates across an over-widened floodplain of volcanic debris (TAG; USFS 1997c; Lisle et. al. 1982).

Other bank stability issues that were noted within the subbasin included:

- Bank cutting is infrequent in the middle and upper reaches of the Silver Lake watershed (Weyerhaeuser 1994). However, the lower Hemlock Creek area is naturally prone to bank cutting and has probably always had comparatively high inputs of fines owing to the geology and geomorphology (Weyerhaeuser 1994).
- Bank erosion from 10% - 30% was noted in Sucker Creek (Weyerhaeuser 1994).
- Bankfull width-to-depth ratios are all >15.0 in the Green River system, which is an indicator of unstable eroding banks and a decrease in channel depth (Haapala 1993).

- The Upper Toutle River Watershed Analysis (USFS 1997c) identified three subbasins (the upper North Fork, the South Fork, and the South Coldwater Creek) as areas of concern due to channel erosion from mudflows.

Large Woody Debris

Large woody debris (LWD) concentrations and recruitment potential is limited in most of the upper Toutle River watershed (USFS 1997c; Lucas 1986; USFWS 1984). Considering the high level of logging activity within the upper Toutle subbasin, LWD concentrations were likely well below historic conditions before the eruption of Mt. Saint Helens. The mud and debris flows after the eruption scoured some stream channels or buried most instream LWD and riparian vegetation adjacent to the stream channel, and left some extremely wide, shallow channels (Jones and Salo 1986). Extensive logging and salvage operations after the eruption removed much of the LWD outside of the National Monument (USFS 1997c).

TAG members rated LWD quantities in almost all watersheds in the Toutle subbasin as "poor". However, for most stream systems there is very little information available. Surveys on the upper Green River system show that in the upper reaches there are tremendous amounts of small, brush-sized LWD created by the blast from the eruption (Haapala 1993). This small LWD has formed pool after pool of close-spaced, poor-quality habitat with little riffle or glide habitat between pools. The lower reaches of the Green River have seen recent timber harvests and LWD quantities are low (Haapala 1993). Lucas (1986) notes that the limited source of LWD within the Green River and within Elk Creek presents major problems for short-term recovery of these systems. Hoffstadt Creek and Bear Creek, and the North Fork Toutle all lack adequate supplies of LWD (Lucas 1986; TAG).

Within the Silver Lake watershed, functional LWD is scarce (Weyerhaeuser 1994; Houpt et. al. 1994). Riparian areas within the watershed on the whole do not now function as sustainable sources of LWD. Near term recruitment potential for LWD is low, owing to a predominance of alder with riparian stands. This combination of factors creates a situation where fish habitat created by LWD (e.g., summer rearing pools and gravel spawning concentrations) is likely to be below potential for some time (Weyerhaeuser 1994).

Riparian recovery has been slow in areas that were inundated by mud and debris flows. The potential recruitment for LWD within most basins is low (USFS 1997c; TAG). LWD recruitment potential has only been measured within the upper portions of the South Fork, North Fork, and Green River systems by the USFS (1997c). Over half of the upper basin within the National Forest has low potential for recruitment of LWD, with 80-100% of its streamside riparian areas in grass/forb – small tree stand structure. Most of this area falls in the upper North Fork and lower portions of the Green River. Almost all of the South Fork and upper Green River also have low recruitment potential, with grass/forb –small tree stand structure covering approximately 50-79% of the riparian corridors (USFS 1997c).

Pool Frequency

Mud and debris flows from the eruption of Mt. Saint Helens filled channels and eliminated or reduced pool habitat within the upper Toutle subbasin for a number of years after the eruption (Lucas 1986; Jones and Salo 1986; USFSW 1984; Cowlitz County 1983). Jones and Salo (1986) measured the percent volume of pool and riffle habitat for a number of streams in the upper Toutle subbasin during a low-flow period in 1984 (see Table 26). Tributaries to the North Fork, downstream from the landslide debris flows, and reaches of the South Fork inundated by mud flows have created new channels or redeveloped old stream beds to approximately pre-eruption levels. Three streams still had minimal amounts of pool habitat (Goat, Maratta, and Herrington), and mean pool depth was generally low in all affected streams except in Goat Creek where pools comprised only 4.7% of the channel (Jones and Salo 1986).

Pool frequency is generally "poor" within the mainstem South and North Forks; however, these systems have likely always had a large percentage of riffle-run habitat (TAG). Heavy sediment loads in these rivers, especially the North Fork, will probably continue to reduce the quality and quantity of pool habitat for some time into the future.

Table 26: Habitat Measurements for the upper Toutle (percent volume).

Stream	Pool %	Mean Depth (cm)	Riffle %	Mean depth (cm)	Glide %
Alder Cr.[1]	61.3	20.4	38.7	14.2	----
Upper Wyant Cr.[1]	90.2	19.4	9.8	11.1	----
Lower Wyant Cr.[3]	88.6	18.6	11.4	11.5	----
Maratta Cr.[2]	22.9	13.4	41.0	11.3	36.1
Hoffstadt Cr.[3]	64.0	18.0	36.0	11.9	----
Goat Cr.[3]	4.7	31.0	92.0	35.2	3.3
Herrington Cr.[3]	47.2	12.2	52.8	11.5	----

Adapted from Jones and Salo 1986

[1]Control section unaffected by volcanic activity

[2]Experienced landslide debris flow impact

[3]Experienced mudflow impact

Haapala (1993) found that the number of pools per mile varied between less than 5 in the lower reaches to over 120 pools per mile in the upper reaches of the Green River. However, pool habitat in the upper reaches was formed by brush-sized debris from the eruption and, in general, the pool quality was poor.

Pool habitat within the Silver Lake watershed is generally poor to fair (Weyerhaeuser 1994). Pool habitat is generally lacking within Sucker Creek, and most pools are formed by bedrock scour. Pools are more abundant in the anadromous reaches of Hemlock Creek than in Sucker Creek, and current rearing conditions were determined to be fair to good overall (Weyerhaeuser 1994). Outlet Creek had the most serious low flow problems within the Silver Lake watershed. Low to non-existent summer flows in Outlet Creek limit available pool habitat, and coupled with high stream temperatures (July stream temperatures measured at 23° C), this creates rearing conditions that are unfavorable or lethal to juvenile salmonids (Weyerhaeuser 1994).

Side Channel Availability

Many of the response reaches within the upper Toutle River subbasin that have unconfined channels have formed wide braided channels in an attempt to accommodate the huge sediment loads they received from the mud and debris flows when St. Helens erupted (Lisle et. al. 1982). Natural processes may eventually form new side-channel habitat that will provide additional rearing and spawning areas for salmonids. However, the formation of riparian cover, instream LWD, and other structural elements that will provide cover and habitat diversity for rearing and spawning within the new side channel habitat will likely be slow.

Information is generally lacking on the quantity and quality of side channel habitat for most areas within the subbasin. Exceptions include the Green River where surveys found that the percentage of side channel habitat within 9 surveyed reaches of the Green River varied between 1.1 % to as high as 5.6% (Haapala 1993), and within the Silver Lake watershed where off-channel and side channel habitat is largely lacking (Weyerhaeuser 1994).

Substrate Fines

The massive debris avalanche and mudflows from the eruption of Mt. Saint Helens buried the North and South Forks and the mainstem Toutle River including the lower reaches of many tributary streams (Cowlitz County 1983). The mudflows that traveled down the North Fork were forced up into the lower reaches of the Green River, covering up much of the spawning habitat for coho and chinook salmon (USFWS 1984; Haapala 1993). In some streams, the massive amount of debris caused sluice-outs that scoured channels to bedrock or boulder pavement. Mudflows and blast deposits caused very high suspended sediment levels and spawning gravels were either embedded with sediments or completely buried (Salo and Martin 1982 as cited in Cowlitz County 1983). Of the larger streams, the Green River and South Fork have recovered faster than the North Fork (USFWS 1984). The Green River has been flushing itself of fine sediments and sediment yields appear to be returning to pre-eruption levels (Lucas, 1986; USFWS 1984; TAG).

Sediment fines and suspended sediments continue to be a major problem within the North Fork and mainstem Toutle Rivers (WDW 1990; Lucas 1986; TAG). Sediments are often highly cemented with fines, and when redds are established they are often suffocated by excessive fines moving through the system (TAG). Annual sediment discharges in the North Fork had not changed appreciably 5 years after the eruption (Lucas 1986), and TAG members felt that fine and suspended sediments were still the major limiting factor in the North Fork and mainstem Toutle Rivers. TAG members stated that the Sediment Retention Structure (SRS) on the North Fork was the major obstacle preventing natural recovery of both the North Fork and the mainstem Toutle downstream. As it exists, the SRS has become the major chronic fine sediment source to downstream habitats (TAG).

TAG members noted that the SRS prevents or at least slows natural recovery of the system like what has been observed in the Green River and South Fork Toutle.

Other stream systems within the upper Toutle subbasin are also recovering from the effects of the eruption. However, the lower reaches of many creeks still contain excessive fine sediments including; Johnson, Wyant, Alder, Studebaker, and Bear creeks (TAG; Lucas 1986).

High road densities within the Toutle basin add to already elevated inputs of fine sediments to the stream channels. Lewis County GIS (2000) measured 4.63 miles of road/square mile within the Toutle subbasin. The USFS (1997c) also measured road densities within 9 subbasins of the upper Toutle River watershed. The mean road density for entire upper basin is only 1.63 miles of road/square mile, which would fall in the "good" category using the Conservation Commission standards. However, the lower Green River subbasin and the South Fork subbasin have high road densities of 6.16 miles of road/square mile and 3.49 miles of road/square mile, respectively (USFS 1997c). TAG members mentioned that many of the private and state road systems within the upper Toutle subbasin are now inaccessible due to the eruption and are likely in need of maintenance and repair. Assessment of these roads is needed.

Fine sediments related to road erosion were identified as a problem within the Silver Lake watershed. Eroding ditches and the long lengths of roads that drain directly to the streams are major sources of fine sediments to streams. Fifty-nine specific road segments drain directly to streams, including 39 road lengths >400 feet, and 18 road lengths > 800 feet. Unvegetated cutslopes also contribute excessive fine sediments (Weyerhaeuser 1994). In-channel sources of fine sediments are limited and localized. The greatest area for input identified by the Silver Lake Watershed Analysis (Weyerhaeuser 1994) was in lower Hemlock Creek. This area is naturally prone to bank cutting and has probably always had comparatively high inputs of fines owing to the geology and geomorphology (Weyerhaeuser 1994).

The processes that typically deliver coarse sediments to streams are relatively inactive within the Silver Lake watershed. Mass wasting is not a significant erosional process in the watershed (Weyerhaeuser 1994). Streambanks are a more likely source of coarse sediments in the system; however, bank cutting is infrequent in the middle and upper reaches of the Silver Lake watershed where coarse sediments are stored (Weyerhaeuser 1994). One consequence of these conditions is that spawning gravels are scarce in the watershed. This is exacerbated by the lack of LWD and other storage elements in the watershed (Weyerhaeuser 1994).

Riparian Conditions

Riparian conditions throughout the subbasin are generally in "poor" condition. Stand structure and composition within Riparian Reserves on the National Forest have been significantly altered by the eruption of Mt. St. Helens, and also by timber harvest and fire (USFS 1997c). An estimated 53% of the Riparian Reserves within the national forest are in early- to mid-successional stages, 9% is in a late-successional stage, less than 1% is in hardwoods, and 37% is in non-forest. There are no figures for private or state lands in the upper watershed area; however, the condition of these lands is predominately early-successional as well (USFS 1997c). Efforts on state and private lands to salvage and replant areas affected by the eruption have resulted in significantly more area in open and closed sapling stands on these lands (USFS 1997c).

Map 11a in Appendix A illustrates the extent of the impacts to the riparian cover in upper watershed. The entire upper North Fork, large portions of the upper South Fork and upper Green River have poor riparian conditions. Lack of riparian cover is considered to be one major causes of elevated stream temperatures in many of the upper Toutle River Subbasin streams including along the Green River (Haapala 1997; Lucas 1985;USFWS 1984), Elk Creek (Lucas 1986), Bear Creek (Lucas 1986), North and South Forks of the Toutle, and Herrington Creek (TAG). Table 27 summarizes Lunetta et. al. (1997) riparian cover data for the Toutle River subbasin. Only 11.6 percent of the subbasin has "good" riparian conditions (>70% late- and mid-seral stage conifer cover), and over 50% has clearly poor riparian conditions (Lewis County GIS 2000).

Riparian conditions within the Silver Lake watershed and Outlet Creek are generally "poor," with deciduous species dominating most riparian zones (Weyerhaeuser 1994; Houpt et. al. 1994; TAG). However, most of the streams are well shaded and riparian conditions are improving (Weyerhaeuser 1994; TAG). Riparian buffers, left after logging along upper Sucker creek, have blown down in many areas (Houpt et. al. 1994).

Table 27: Riparian Conditions Summary in the Toutle River Subbasin

Subbasin	Riparian Condition	Stream Miles	Percentage
Toutle	Good	114.63	11.6
	Unknown	379.82	38.3
	Poor	497.52	50.2
Totals		*991.97*	*100.0*

From Lewis County GIS 2000; Lunetta et. al. 1997

Water Quality

Although no stations have collected continuous stream temperature readings in the upper Toutle Subbasin since the eruption of Mt. Saint Helens, it is anticipated that streams are exceeding State Water Quality Standards (16° C) due to several factors. These include loss of riparian vegetation in tributary streams, channel widening from the mudflows that traveled down the North and South Forks of the Toutle, and channel widening from the introduction of large amounts of tephra (USFS 1997c). Stream water temperature is a major factor influencing the composition and productivity of aquatic systems in the upper Toutle Subbasin (USFS 1997c; USFWS 1984). Lucas (1986) notes that one of most pressing problems for fish on the South Fork Toutle, Green River, and within Elk Creek is high stream temperatures. Water temperatures often exceed state water quality standards near the mouth of the Green River at the Toutle River Hatchery (Haapala 1993). Data collected at the hatchery shows that maximum water temperatures exceeded

20° C in the summer months of 1991, and 1992. Even the mean temperature reached near 19°C in the month of July 1991 (Haapala 1993). High temperatures within the main channel of the Green were considered the main factor limiting salmonid growth production, and recovery in 1982 (MSHNVM 1982), and in 1993 (Haapala 1993).

Stream temperature monitoring from late 1950 through September 1967 found that water temperatures ranged from 0.0°C to 22.2°C at RM 16.4 in the Toutle River. About half of the Toutle River July and August maximum temperatures were greater than 18.0°C, and about 15 to 30 percent of the June and September maximum temperatures were greater than 18°C (Higgins and Hill 1973 as cited in Harza 1999a).

High suspended sediment loads and turbidity are considered major limiting factors within the North Fork and mainstem Toutle Rivers (TAG). These high suspended-sediment loads largely restrict the suitable spawning and rearing habitat within the North Fork Toutle watershed to tributary streams (TAG; Lucas 1986).

Water quality is also a concern within the Silver Lake watershed. A decline in water quality of Silver Lake, as evidenced by the growth of nuisance vegetation, has prompted several investigations into the sources of this decline. Results of these studies concluded that Silver Lake is in an advanced state of eutrophication (Weyerhaeuser 1994). Nutrients that fuel this condition were found to originate from both natural and anthropogenic sources. The natural phosphorus and nitrogen levels in soils within the watershed are comparatively high (Weyerhaeuser 1994; Houpt et. al. 1994). Both applications of forest fertilizers and residential septic systems are likely contributors to elevated nitrogen and phosphorus levels within the watershed (Weyerhaeuser 1994; Houpt et. al. 1994).

Elevated water temperatures within Silver Lake watershed are also a concern especially within the lower reaches of Hemlock Creek, within a tributary to Sucker Creek, and within Outlet Creek (Weyerhaeuser 1994; Houpt et. al. 1994).

Water Quantity

In general, subbasins within the Upper Toutle Watershed Analysis area (USFS 1997c) are recovering from the 1980 eruption of Mt. Saint Helens. The analysis found that 55% of the subbasins in the area have the potential for increased peak flows of 10% or greater due to loss of the mature conifer vegetation component, and the degree of impact is likely underestimated (USFS 1997c). Currently, 47% of the upper basin is in early successional timber stands compared to a historic range of 3% to 42% (USFS 1997c). WDF/WDW (1993) states that the basin is hydrologically immature due to effects of the eruption and to the extensive pre- and post- eruption logging. As such, the streams are likely subjected to increase peak flows that can cause bed and bank scour and channel shifting to the detriment of egg and fry survival. Roading has added to increased peak flow concerns in the upper basin by increasing stream lengths in the watershed by 0-63% (USFS 1997c). Approximately 370 extra miles of stream network have been added in the upper watershed by roads (USFS 1997c).

Data on stream flows is generally lacking in much of the Toutle subbasin. However, Weyerhaeuser (1994) measured summer rearing potential within anadromous streams in the Silver Lake watershed. Outlet Creek had the most serious low flow problems within the Silver Creek watershed. Low to non-existent summer flows in Outlet Creek limit available pool habitat, and coupled with high stream temperatures (July stream temperatures measured at 23° C) this creates rearing conditions that are unfavorable or lethal to juvenile salmonids (Weyerhaeuser 1994).

Biological Processes

The Conservation Commission is using the number of stocks meeting escapement goals as a surrogate measurement of nutrient levels within stream systems (see Habitat Rating Standards in Appendix B). Escapement for most anadromous stocks in the Toutle is well below historic levels (WDF et. al. 1993; LCSCI 1998), and the lack of carcasses contributing nutrients to the systems may be limiting production within the subbasin.

Escapement goals for wild steelhead in the mainstem and North Fork Toutle and for the Green River have not been established. However, steelhead escapement goals are not being reached for the South Fork Toutle, and recent studies indicate the South Fork stock is depressed (LCSCI 1998). In 1951, an estimated 6,500 fall Chinook returned annually to the Toutle to spawn. The natural spawn escapement in 1991 was estimated at only 33 fall chinook in the South Fork and 126 fall chinook in the Green River. Both of these fall chinook stocks are considered depressed (WDF et. al. 1993). The Toutle River, South Fork Toutle River, and Green River coho stocks are also considered depressed based on chronically low production (WDF et. al. 1993). At one time, "large numbers" of coho spawned near in the mainstem near Spirit Lake and in over 20 tributaries to the Toutle (WDF 1951). Today, natural spawning is presumed to be quite low and subsequent juvenile production is below stream potential.

Predation and competition from other fish species potentially limits the production of salmon and steelhead within the Silver Creek watershed (Weyerhaeuser 1994). There are approximately 25-30 fish species within the watershed, and approximately one-half are non-native fishes introduced to provide a warm-water fishery.

Lower Cowlitz River Subbasin

This subbasin includes the mainstem Cowlitz River and its tributaries from the Toutle River confluence (RM 20) to Mayfield Dam (RM 52) and tributaries west of the mainstem Cowlitz between Longview and the Toutle River confluence (see Map 4 for basin boundaries). Larger tributaries in this subbasin include Arkansas, Olequa, Lacamas, Salmon, and Mill creeks. There are two streams named "Mill Creek" in this subbasin.

Knowledge on condition of habitat limiting factors within many stream systems of the Lower Cowlitz subbasin is often limited. Data is available from personal observations of

TAG members and from various habitat stream surveys. Foot-by-foot, quantitative, stream-habitat surveys have been conducted by Cowlitz Conservation District for the following streams in this subbasin: Leckler, Arkansas, Delameter, Monahan, Tucker, Baxter, and Whittle creeks. These surveys included all tributaries with a gradient of less than 16 percent and a wetted width of greater than 2 feet. Habitat surveys in this subbasin were performed between 1994 and 1999. Additional habitat data in this report was obtained from reports published by David Evans and Associates, Inc. and Jones & Stokes Associates, Inc. for Curtis, Little Salmon, Skook, and Jones creeks. This information was collected for Lewis County culvert inventories and typically discussed stream habitat for several hundred feet above and below the culvert.

Historical information for this area was provided by the Ecosystem Diagnosis and Treatment (EDT) analysis (Mobrand Biometrics 1999). The summary statements about original habitat, circa 1820, were presented as assumptions, based in some cases on empirical observations, while in others (historic descriptions) are inferred from various sources identified and documented through the EDT process. Statements about changes to survival conditions are with respect to fall chinook, which was used as the diagnostic species.

Historically, spawning grounds in this basin produced 20 percent of the fall chinook and 38 percent of the steelhead in the Cowlitz basin. Now, 100 percent of fall chinook and 60 percent of steelhead spawning in the Cowlitz River mainstem occurs in this reach, because the dams have blocked most of the historical habitat (Mobrand Biometrics 1999).

Access

The system of dams on the Cowlitz River is the most significant factor limiting salmonid habitat in the Cowlitz River basin. Mayfield Dam blocks access to approximately 80 percent of the available steelhead habitat in the Cowlitz basin (WDF et. al. 1993). Ninety-six percent of the spring chinook production in the Cowlitz River was estimated to have occurred above Mayfield Dam in the years 1950 to 1961 (Easterbrooks 1980). The Historic Anadromous Distribution with Passage Barriers (Map 3a) shows major access problems in WRIA 26.

Fish passage on the mainstem Cowlitz River is good throughout this subbasin to the Barrier Dam at RM 49.5. Culverts in this subbasin are currently being surveyed according to WDFW parameters for fish-blocking characteristics. The survey is scheduled to be completed in 2000. The following access issues are known to block fish passage in WRIA 26:

- Westover Creek, near Longview, has two sets of blocking culverts and an outlet fall to the Cowlitz River during average and low flows (TAG).
- McCorkle Creek, just north of Longview, also has poor fish passage due to a flood gate and pump station with a flood-retention basin near the creek mouth. It is unknown if there is any anadromous habitat upstream of these blockages.

- Leckler Creek has 6 culverts on its mainstem. One culvert on a tributary may not be in fish-bearing waters. The lower-most culvert partially blocks 19,000 feet of salmonid habitat (CCD unpublished).
- Monahan Creek, a tributary to Arkansas Creek, has a box culvert near its mouth that blocks most upstream migrants. WDFW biologists have identified Monahan Creek as having the highest quality habitat in southwest Washington. Funds are already in place to repair this blockage (TAG).
- Tucker Creek has a culvert at its mouth, blocking approximately 0.8 miles of anadromous fish habitat (CCD 1995).
- There is a fish ladder on Monahan Creek that the TAG has identified to be a barrier. It is frequently clogged due to a lack of maintenance (CCD 1995).
- An unnamed tributary to Stillwater Creek, an Olequa Creek tributary, has a blocking culvert at the 900 Road that is scheduled to be replaced in the summer of 2000. It blocks approximately one mile of anadromous fish habitat (TAG).
- Whittle Creek has three blocking culverts. From the lower-most to the upper-most culvert, they each block 400 feet, 2000 feet, and 200 feet of anadromous fish habitat, respectively (CCD 1995). Whittle Creek also dries up from its mouth to Umiker Road in the summer (CCD unpublished).
- Ferrier Creek, an Olequa Creek tributary, has a blocking culvert and a dam near its mouth that block over one mile of anadromous fish habitat (Lewis County 1997).
- Foster Creek has a culvert at the Interstate 5 crossing that blocks approximately 2 miles of habitat (Lewis County 1997).
- Skook Creek has 2 blocking culverts at Howe Road, which is 1.1 miles above its mouth and blocks approximately 4 miles of anadromous fish habitat (David Evans and Associates 1998).
- Blue Creek is blocked at the Cowlitz Salmon Hatchery. Steelhead and cutthroat trout are planted above this barrier (TAG).
- Mill Creek is a tributary to the Cowlitz and is located just below Barrier Dam. It has an impassable, hydroelectric dam over one mile from its mouth. It blocks approximately 5.2 miles of anadromous fish habitat (TAG).
- Cowlitz River Barrier Dam (RM 49.5) blocks most anadromous fish with a 15-foot-high, electrified barrier. Fish occasionally jump over the barrier, and at times have been released above the barrier (TAG).
- Cowlitz River Mayfield Dam (RM 52) is a total barrier and does not have volitional, fish-passage facilities.

Floodplain Connectivity

Floodplain connectivity on the mainstem Cowlitz River is generally good in this subbasin (TAG). The river is incised into bedrock in the two-mile reach between Barrier Dam and Mayfield Dam, and there are scattered areas of revetment along the mainstem. Compared to historical levels though, there have been losses in key habitat areas and habitat diversity for most salmonid life-stages due to channel simplification and diking (Mobrand Biometrics 1999). From 1939 to 1996, there has been a decrease in the total square feet of habitat per mile available to chinook and steelhead (Mobrand Biometrics 1999).

The following floodplain information is known about Cowlitz River tributaries in this subbasin:

- Westover and McCorkle Creek, near Longview, are incised and run through subdivisions in the lower reaches. Dredge spoils have been deposited in lower Westover Creek floodplain and the creek has been straightened and channelized (TAG).
- The lower 2 miles of Leckler Creek is incised. Floodplain connectivity in upper Leckler Creek is good, except where residents are dredging or deepening the channel (CCD unpublished).
- Lower Arkansas and lower Delameter creeks pass through agricultural land in an unconfined entrenched channel. This area was impacted by the Mt. St. Helens mudflows. In response, the U.S. Army Corps of Engineers straightened and deepened the channel beyond natural conditions. Annual high flows no longer top the banks (CCD 1995).
- Lower Whittle Creek has poor floodplain connectivity. It runs through fairgrounds, a gravel pit, agricultural land, and then residential land in the first 15,000 feet. The reach through the residential area is incised. Above this reach, the connectivity is good (CCD unpublished).
- The lower few miles of Olequa Creek is incised into mudstone and has some areas of rip rap (TAG).
- Rip rap has been placed in the lower one-half mile of Salmon Creek (near Castle Rock), and also in areas above this reach (TAG).

Bank Stability

Bank stability conditions on the mainstem Cowlitz River are generally unknown between Olequa Creek and Barrier Dam (TAG). From Barrier Dam to Mayfield Dam the river is mostly confined within a bedrock canyon and bank stability is good (TAG). Bank stability is poor in the reach between the Toutle River (RM 20) and Olequa Creek (RM 25). The TAG thought it may be related to channel incision, but the cause is unknown. The EDT analysis stated that stream stability in the Cowlitz mainstem below the dams has been enhanced due to flow regulation at hydroelectric projects (Mobrand Biometrics 1999).

Bank stability conditions in the tributaries are largely unknown, except for stream-surveyed areas. The following comments address bank stability concerns in the lower Cowlitz subbasin:

- Leckler Creek has poor bank stability. Thirty-five percent of the creek is accessible to cattle (CCD unpublished).
- Lower Arkansas Creek has poor bank stability from the mouth to the West Side Highway (CCD 1995).
- Delameter Creek bank stability is poor in the agricultural area from its mouth to Tucker Creek. (CCD 1995).

- Seventy-three percent of the agricultural ground in Whittle Creek has cattle access and bank stability problems. The bank stability in the lower 6,000 feet of this stream is rated poor (CCD unpublished).
- Bank stability is good in Olequa Creek from the mouth to Stillwater Creek. Above this reach bank stability is fair. Banks are high and consist of hardpan, alternating with pockets of gravel (TAG).
- Salmon Creek has bank stability problems, likely due to the nature of soils in the area (TAG).
- Some areas of Foster Creek have stability problems associated with cattle grazing (TAG).

Large Woody Debris

Historically, the Cowlitz River mainstem had abundant amounts of large wood contained within the channel, which included large logjams (Mobrand Biometrics 1999).

Harza Engineering (2000) studied LWD in the mainstem Cowlitz using aerial photographs from 1939, the mid-1960s, and 1996. For each year the average was 12, 6, and 11 pieces of LWD per mile, respectively. In 1939, there were many piles of logs beached on gravel bars at the edge of the river, which would be within the channel at high flows. In the mid-1960s, the log piles were noticeably absent from the entire length of the river and the channel was relatively clean of wood. In 1996, the channel was still relatively clean of wood, but appeared to have more wood than in the mid-1960s. The pattern of LWD distribution between time periods is likely a result in the change in forest and land-use practices that have occurred during the 57-year period, the construction of the dams, and floods in the years immediately prior to the 1939 photography.

In 1939, the supply of wood from harvest practices, along with the huge flood, resulted in the transport of LWD out of tributary streams and into the mainstem Cowlitz. However, much of the wood was piled along the margins of the channel rather than in or spanning the wetted channel areas and so did not enhance aquatic habitat during low flows. Wood accumulations did provide benefits to fish in some side-channel areas. During the early 1960s, fisheries managers were promoting the removal of LWD jams to improve instream habitat, and most timber areas were harvested prior to 1950. These practices resulted in less LWD transported to the river. High river flows in 1962 and 1965 also transported wood out of the stream (Harza 2000).

Construction of the dams changed both the flood flows and input of LWD from upstream areas. Dam-regulated flows did not allow high peaks to occur, and the dams also halted input of LWD from the upper Cowlitz basin. However, by the mid-1980s, the understanding of LWD function in streams resulted in discontinuing the stream-cleaning practices. In addition, second-growth harvest was beginning to occur in the lower Cowlitz, and riparian buffers have left large trees adjacent to channels that can be recruited during floods. These factors have made more wood available to the river (Harza 2000).

LWD concentrations within the mainstem Cowlitz and tributaries in this subbasin are considered "poor", based on observations by TAG members. Stream-survey data for the Arkansas watershed, Leckler Creek, and Whittle Creek also rated LWD as poor (CCD 1995). Lack of woody debris in smaller tributaries to the lower Cowlitz subbasin is caused by the combination of extensive logging within riparian areas and past stream-clearing efforts (Mobrand Biometrics 1999).

Pool Frequency

Pool habitat is summarized in Table 28 for three different flows in the mainstem Cowlitz River from the Barrier Dam to its mouth (50 miles)(Harza 2000).

Table 28: Percent area of each habitat type found below the Barrier Dam at various flows (cfs).

Flow (cfs)	Pool	Glide	Riffle	Rapid	Average Width (ft)
2,140	16 (17%)	59 (61%)	19 (20%)	2 (2%)	237
5,000	12 (13%)	73 (76%)	9 (9%)	2 (2%)	263
10,000	3 (3%)	88 (92%)	4 (4%)	1 (1%)	307

Adapted from Harza 2000

Stream surveys in the 1930s (McIntosh 1995) estimated pool habitat in the following creeks: Monahan (50 pools per mile), Delameter (26), Olequa (20), Stillwater (8), Lacamas (26), and Salmon (18) (Harza 1997b). Pool frequency for streams of this size is considered to be good at 26 pools per mile.

Table 29: Summary of habitat types in selected survey reaches

			Percent Area					
Stream/Reach	**Survey Length (feet)**	**Total Habitat Area(ft^2)**	**Pool**	**Riffle**	**Glide**	**Cascade**	**Side Channel**	**Step/Falls**
Olequa Creek (1)	3,217	204,180	12	14	74	0	0	0
Olequa Creek (2)	1,000	---	5	20	75	0	0	0
Lacamas Creek	3,687	109,005	22	8	71	0	0	0
Salmon Creek *(in Lewis County)*	3,094	121,580	17	16	60	0	7	0
Rock Creek	500	---	20	10	70	0	0	0
Blue Creek	2,500	---	40	30	30	0	0	0
Mill Creek *(near Barrier Dam)*	2,500	---	15	45	40	0	0	0
Otter Creek	200	---	20	50	30	0	0	0
Campbell Creek	1,500	---	20	40	40	0	0	0
Campbell Creek	1,160	---	5	60	25	10	0	0
King Creek (1)	1,500	---	25	50	25	0	0	0
King Creek (2)	1,300	---	5	65	30	0	0	0
King Creek (3)	600	---	5	45	50	0	0	0

Adapted from Harza 1997.

The pool frequency information available for tributaries in this subbasin is from published sources or habitat stream surveys. Cowlitz Conservation District habitat stream surveys in the mid- and late-1990s showed poor pool frequencies in Leckler, Arkansas, Delameter, Monahan, Tucker, Baxter, and Whittle creeks. Eighty percent of Leckler Creek has a low quantity of pools (less than 30 percent), or an excessive quantity of riffle habitat. Wood was identified as the principal pool-forming mechanism in the watershed, and there is a lack of instream LWD in this creek (Cowlitz Conservation District, unpublished). Pool quality in Skook Creek was generally reported to be "very good" from the mouth to Howe Road. Above Howe Road, pool quality appears to be "excellent" (David Evans and Associates 1998a). However, pool frequencies were not given, and their criteria may not be equivalent to criteria used in this limiting factors analysis. Table 29 shows pool habitat area in selected reaches of lower Cowlitz tributaries.

Side-Channel Availability

Historically, the Cowlitz River mainstem from the Toutle River (RM 20) to Barrier Dam (RM 49.5) had a gradient of less than 0.25 percent and flowed across an alluviated, lowland plain. The river was unconstrained and had a moderate- to highly-meandered channel, with substantial off-channel habitat (sloughs and oxbows) and some side-channel complexes (Mobrand Biometrics 1999). The mainstem Cowlitz River from Barrier Dam (RM 49.5) to Mayfield Dam (RM 52) is mostly in a confined, canyon area and does not have naturally occurring side-channel habitat (TAG).

Previous studies have identified side channels as important for chinook spawning and rearing (Harza 1997c). Within the range of the historical study, side-channel habitat has increased relative to total habitat area. However, the quality and quantity of existing, side-channel habitat is jeopardized at low flow (less than 2,140 cfs). All surveyed side-channels at the intermediate flow (5,000 cfs) contain flowing water, and most side channels at intermediate flow have diverse habitat types with a variety of suitable depths and velocities (Harza 2000).

All palustrine wetland types have increased, while riverine, unconsolidated-shore wetland types have decreased (exposed gravel bars along the river) since 1939. The decrease in exposed gravel bars is the greatest wetland change within the 1,000-foot river buffer (Harza 2000).

Gravel mining has eliminated historic side-channel habitat at the following sites:

- RM 27.5: There is no indication in the aerial photographs that this was side-channel habitat;
- RM 34.5: In 1939 aerial photographs, this area was a complex, braided channel. In 1964 aerial photographs, it was a wetland complex with a side channel connected to the main river;
- RM 36.5: In 1939, there was a relic, side channel; and in 1964, this was forest and agricultural land.

Side channels upstream of RM 30.5 have substrate in sizes that provide both good cover to juvenile salmonids and good spawning habitat for adults. Side channels at and below RM 30.5 provide good or acceptable spawning substrate, but due to a more homogenous distribution of particle sizes do not provide much substrate cover for juvenile salmonids (Harza 2000).

The condition of side channel habitat is generally unknown for most of the smaller streams in the subbasin. Cowlitz Conservation District has unpublished data on various habitat conditions in the Arkansas Creek basin that should provide additional data in the near future.

Substrate Fines

There has been a severe reduction in recruitment of gravel in the Cowlitz mainstem, between Barrier Dam and Mayfield Dam (Mobrand Biometrics 1999). A study of the supply and transport of bedload-sized sediment was completed for the lower Cowlitz River between Mayfield Dam and the Toutle River (Harza 1999a). The bedload-transport capacity between Mayfield Dam and Barrier Dam far exceeds output. As a result, much of the gravel and smaller sediment has been transported out of this reach and has not been replenished from upstream sources. The riverbed is lined with cobbles and there is little gravel-sized sediment in the channel. In the reach between Barrier Dam and the Cowlitz Trout Hatchery, transport capacity also exceeds gravel input. The majority of this reach also lacks gravel-sized sediment (Harza 1999b).

In the reach between the Cowlitz Trout Hatchery and the Interstate-5 Bridge, the Cowlitz River meanders across a wide, alluvial plain. In this reach, supply of sediment from river-bank cutting exceeds the current transport capacity. There is ample gravel in the channel, and sediment from this reach is also supplied to down-stream reaches (Harza 1999b).

The quantity and distribution of suitable substrate does not appear to be a limiting factor to spawning chinook in the Cowlitz River between Barrier Dam and the Toutle River. Suitable substrate is dominant from the mouth of the Toutle River (RM 20) to about RM 44.5 in all habitat types except rapids. About one-half of the channel area from RM 44.5 to the Barrier Dam is dominated by suitable spawning substrates (Harza 1999a).

The TAG members stated that there are basically no substrate fines in the mainstem between the Barrier Dam and Mayfield Dam because the dams block sediment moving downstream. Substantial increases in fine sediments to the mainstem below the Barrier Dam are attributed to land-use activities primarily within this subbasin (Mobrand Biometrics 1999). The EDT analysis found a moderate degradation in sediment load over historic conditions (Mobrand Biometrics 1999).

Road density is used as a surrogate to indicate probable fine-sediment problems, and densities above 3.0 miles per square mile are considered to be high (see Appendix B Habitat Rating Standards). The road density in the Lower Cowlitz subbasin is 4.9 miles per square mile, and 31 percent of the anadromous streams have stream-adjacent roads (Lewis County GIS 2000). Tributaries in this subbasin are generally rated as "poor" for fine sediment conditions, Conditions were identified in the following creeks from stream habitat surveys and TAG member observations:

- Leckler Creek has a poor rating for fine sediments. Potential sources of these fine sediments include the geology within the basin, the lack of LWD, poor riparian conditions, and cattle grazing. Twenty three percent of the total streambank length

(55 percent of the agricultural land use area) of Leckler Creek is accessible to livestock (CCD unpublished).
- Lower Arkansas and lower Delameter creeks, below the Kline Road and upper Delameter Road crossings, contain naturally high levels of fine sediments. However, fine sediment conditions are poor almost throughout the Arkansas Creek watershed. Cattle grazing may have a significant impact on fine sediment concentrations, because they have access to 89 percent of the streams in the Arkansas Creek watershed. High road densities in this area are also a concern (CCD 1995).
- Thirty-one mass failures were identified in the Arkansas watershed. Failures closely correspond to soils with high and moderate slippage. Three of the sites have low soil-slippage limitations and were associated with roads (CCD 1995).
- Upper Delameter and Tucker creeks have a poor fine-sediment rating. Road densities and road conditions in this area are a concern (CCD 1995).
- Monahan Creek has had fine-sediment problems in the past. Industry has addressed some of the sediment problems on forest lands (CCD 1995).
- Whittle Creek has a poor rating for substrate fine sediments. The lower half of the creek has been modified by agricultural practices and stream work performed after the 1980 Mt. St. Helens eruption. The upper half has been logged in the last 5 to 10 years and is also rated as poor. The uppermost 1000-foot reach surveyed has a bedrock substrate. Twenty-eight percent of the watershed is used for grazing, and cattle have access to twenty percent of Whittle Creek (CCD unpublished).
- The first reach of Olequa Creek that was recently surveyed has embedded substrate over 50 percent of the area. "Embedded" is defined as greater than 35-percent fines in the substrate (CCD unpublished).
- Lacamas Creek was surveyed in a 3,687-foot reach. It has 33 percent of its area with at least 35-percent, embedded substrate (Harza 1997b).
- Salmon Creek was surveyed in a 3,094-foot reach. It has 20 percent of its area with at least 35-percent, embedded substrate (Harza 1997b).
- Substrate fines in lower Lacamas Creek were rated good. The upper Lacamas is a low-gradient system with wetlands and naturally finer substrates (TAG).
- Skook Creek has been described by David Evans and Associates (1998a) as having clean gravel tailouts from pools from the mouth to Howe Road. Between Howe and Spencer Roads, there are relatively-long stretches of clean gravels with a range of gravel sizes, depending on velocities. Below Spencer road, Skook Creek received a fair rating for fine sediments (TAG). Above Spencer Road, the land use is primarily agriculture and rural residential (David Evans and Associates 1998a).
- The King Creek watershed (tributary to Olequa Creek) has erosion problems that could be contributing fine sediments to the stream (TAG).
- Lower Blue Creek received ”poor” fine sediment rating from the TAG.
- Fine sediment conditions in Foster Creek were also rated as "poor" (TAG).

Riparian Conditions

Historically, riparian areas in the Cowlitz River mainstem from the Toutle River to Barrier Dam were comprised of both deciduous and coniferous trees with abundant wetlands. Prairies were likely present. From the Barrier Dam to Mayfield Dam, the hillslopes and canyon walls were forested with large coniferous species (Mobrand Biometrics 1999). According to the limiting-factors criteria for riparian cover, few areas in this subbasin would be currently rated "good," because riparian areas lack mature conifers and adequate buffers widths.

Riparian cover types for the mainstem Cowlitz River were mapped by Harza (2000) for an area covering 1,000 feet on each side of the river channel. The largest cover types from 1939 to the present are the three forested types (conifer, deciduous, and mixed) and the meadow/grassland type. These four types together account for over 85 percent of the total riparian area mapped. The total area of forested types remains relatively constant since 1939, but there is a decrease in the conifer type and an increase in mixed and deciduous types (Harza 2000).

A significant change in cover-type distribution in the mainstem occurs in the riverine, unconsolidated-shore, cover type. The gravel bars today have more vegetative cover than in 1939. It is possible that the gravel bars were flooded more often before the dams controlled flood flows (Harza 2000).

Other notable changes in the distribution of cover types since 1939 include a decrease in the meadow/grasslands cover type. This change is likely due to the conversion of grassland areas to agricultural use, or to an encroachment of shrubs in abandoned fields. Residential use has also increased along the river corridor, mostly since the mid-1960s (Harza 2000).

In general, riparian conditions in the lower Cowlitz tributaries are poor due to land-use practices that altered riparian zones. Map 11a in Appendix A illustrates the extent of the impacts to the riparian cover in the lower Cowlitz subbasin (data from Lunetta et. al. 1997). Table 30 summarizes Lunetta et. al. (1997) riparian cover data for the Toutle River subbasin. Only 5.5 percent of the subbasin has "good" riparian conditions (>70% late- and mid-seral stage conifer cover)(Lewis County GIS 2000). The majority of riparian habitat within the Lower Cowlitz Subbasin is clearly in "poor" condition (see Map 11a in Appendix A)(Lewis County GIS 2000). In some cases, the streams are adequately shaded but most areas do not have an adequate coniferous component or buffer width.

Table 30: Riparian Conditions Summary of Lower Cowlitz Subbasin

Subbasin	Riparian Condition	Total Stream Miles	Percentage
Lower Cowlitz	Good	37.75	5.5
	Unknown	290.51	42.1
	Poor	361.28	52.4
Total		689.54	100.0

Lewis County GIS 2000; Lunetta et. al. 1997

The following riparian conditions were identified from stream habitat surveys or by TAG members:

- Overall, Leckler Creek has poor riparian conditions. The lower 2000-foot section has a riparian zone consisting of hardwoods, with an average buffer width of approximately 72 feet (CCD unpublished).
- Lower Arkansas and lower Delameter creeks have poor riparian conditions. The trees, when they are present, are immature, and the buffer does not meet the 75-foot criteria (CCD 1995).
- Upper Arkansas Creek is in fair condition. There is good stream shading, but the trees are immature and the buffer is inadequate (CCD 1995). This area is primarily used for pasture land and Christmas tree farming.
- Upper Delameter Creek and Tucker Creek have an overall rating of “fair”. The trees provide good shade, but they are immature and the buffer width is narrow. Riparian conditions are poor in the pastureland on Delameter Creek from the first, unnamed tributary to the confluence of Tucker Creek (CCD 1995).
- Overall, Monahan Creek has poor riparian conditions. The lower reaches of the creek are in fair shape, but the trees throughout the watershed are immature and the buffer width is less than 75 feet (CCD 1995).
- Whittle Creek has poor riparian conditions along the lower 15,000 feet and fair conditions along the upper 15,000 feet. Immature conifers dominant the east side of the creek, and the west side is a mixture with mostly hardwoods with some mature conifers (CCD unpublished).
- Olequa Creek is dominated by deciduous trees and pasture land. Riparian zones in agricultural areas are typically one-tree wide (TAG).
- Historically, riparian zones in Lacamas Creek were dominated by hardwoods with some cedar trees. Current conditions for most of the stream are unknown (TAG).
- Riparian zones are rated poor in Salmon Creek. The major land use is private, forestland. There is some shade on this stream, but the buffers are narrow.
- Skook Creek riparian areas appear to be fair from the mouth to Spencer Road. Above this, the watershed was a natural prairie and is now used for agriculture (TAG).
- Foster Creek was given a poor rating (TAG).

Harza surveyed three major tributaries in the lower Cowlitz subbasin for the percentage of the stream covered by vegetation (percent cover). Table 31 summarizes the findings for percent cover for selected reaches in Olequa, Lacamas, and Salmon Creeks (Harza 1997a).

Table 31: Percentage of habitat units assigned each percent-cover category.

Stream	0 – 5 %	6 – 20 %	21 – 40 %	> 40 %
Olequa Creek	13	38	13	38
Lacamas Creek	19	38	38	5
Salmon Creek (Lewis County)	0	33	27	40

Harza 1997

Water Quality

Water quality is generally good for the lower Cowlitz River mainstem. Overall, the EDT analysis concluded that there has not been a substantial change in water quality over historic levels for the mainstem Cowlitz River in this subbasin. There has been little change in dissolved oxygen from historic conditions. There is a slight temperature increase from approximately RM 33 to approximately RM 29, then a moderate increase to the Toutle River confluence. Historically, water temperatures in the mainstem Cowlitz River were cool during early- to mid-summer, which is highly suited to salmonid growth. Temperatures would be warmer in late summer and early fall, although not excessively warm for good, salmonid growth and survival. Flow regulations by the dams increase late-summer flows over historic levels, and provide cooler water through deep-draft releases (Mobrand Biometrics 1999).

The following observations have been made about water quality in the lower Cowlitz mainstem:

- Recording thermographs measured temperature on the Cowlitz River at two sites in this subbasin. Maximum, daily-maximum temperatures downstream of Mayfield Lake were measured at 14.0, 13.2, and 13.4°C in 1997, 1998, and 1999, respectively. Maximum, daily-maximum temperatures downstream of the Interstate-5 bridge were measured at 16.0°C and 14.8°C in 1997 and 1998, respectively. The Class A standard of 18.0°C was not exceeded in any measurements (Harza 2000).
- The state standards for all classes of streams and lakes require that total dissolved gas (TDG) is not to exceed 110 percent at any time. Studies conducted in 1975 concluded that measurements only exceeded 110 percent during severe flood events of 45,000 to 55,000 cfs. The highest measured TDG values were caused by spill over both dams, resulting in TDG levels of 119 percent at Harmony Bridge in Mayfield Lake, 127 percent 0.25 mile upstream of Barrier Dam, and 121 percent downstream of Barrier Dam. High TDG levels extended down the Cowlitz River during this storm event, as seen by a measurement of 120 percent at the Cowlitz Trout Hatchery the following day (Harza 1999a).
- One sample collected from the Cowlitz River at Toledo exceeded state standards for dissolved and total lead. The results were 4 and 5 mg/L, respectively. The following results are also available for this sampling site, beginning in 1971: color, conductivity, dissolved oxygen, pH, suspended solids, ammonia, nitrate, nitrite, phosphorus, alkalinity, fecal coliform, and flow (USEPA, STORET database).

In general, where there is data available, lower Cowlitz tributaries have elevated temperatures, likely due to a lack of riparian shading. The following water quality measurements have either exceeded Class A state standards, or are above background levels:

In the Arkansas Creek watershed, the following observations were made:

- Recording thermographs were installed at three locations in 1994. Maximum daily temperatures exceeded the Class A standard of 18.0°F almost daily through July and

August at the mouth of Delameter Creek and on Arkansas Creek, just upstream of the Delameter confluence. Minimum daily temperatures indicated that elevated temperatures persisted throughout the day from the end of July and early August. The temperature at the confluence of Delameter and Tucker creeks never exceeded the Class A temperature standard (CCD 1995).

- Delameter Creek had significantly-high, fecal coliform levels at four sites, which were sampled three times from late May to late July 1992. Averages at these sites were 1,600, 755, 524, and 185 organisms/100 mL. The state standard is less than 100 organisms/100 mL. Winter concentrations were not as significant as summer concentrations, possibly due to higher stream flows causing a diluting effect. These results indicated that source(s) of fecal coliform are persistently high throughout the year. This stream reach had 14 residences and cattle grazing with access to the stream. The houses are built on soils with severe limitations for septic systems due to low permeability (CCD 1995).
- Dissolved oxygen concentrations were collected in lower Arkansas and Delameter creeks in during a spring storm event in 1992 and during a dry period in early summer 1992. Levels were slightly lower than the Class A state standard of greater than 8.5 mg/L, which causes concern for possible mid-summer levels. These areas have little vegetative cover and a low gradient (CCD 1995).
- Total nitrogen and total phosphorus did not appear to be excessively high in lower Arkansas and Delameter creeks in the 1992 samples (CCD 1995).
- Total suspended solids (TSS) were analyzed from samples collected in Delameter creek on three consecutive winter days. There was significantly more rainfall on the third day, and TSS results were up to 30 times higher than the previous days (CCD 1995).

The following data was reported for Olequa Creek:

- Olequa Creek was sampled by the Washington Department of Ecology in 1995 as part of a state-wide, pesticide-sampling program. Several small tributaries flow through or near several Christmas-tree farms, which is the primary commercially-grown crop in the area and the most likely source of pesticide contamination. Samples were collected at the bridge on Highway 506 in Vader, upstream of the Stillwater Creek confluence in April, June, August, and October. Atrazine was detected in the April, June, and October samples at 0.025, 0.30, and 0.020 μg/L (parts per billion), respectively. The 0.30 μg/L level was the highest concentration yet recorded for atrazine by Washington State Pesticide Monitoring Program. The only pesticide detection in August was pentachlorophenol (0.028 μg/L). Six herbicides were detected at low levels in the October samples. Four of these are commonly used for forest management, but atrazine is the only one registered for use on Christmas trees in Washington. Atrazine was the only pesticide detected more than once (WDOE 1998).
- The Washington Department of Ecology (Ecology) also analyzed Olequa Creek samples for the following parameters during the above-mentioned, pesticide-monitoring program: total organic carbon, total suspended solids, nitrate/nitrite, conductivity, and pH. Results were within State Class A standards (WDOE 1998).

- Ecology measured temperature in Olequa Creek four times in 1995. Results were as follows; April, 2.8°C; June, 13.9°C; August, 17.1°C; and October, 13.7°C (WDOE 1998).

Stream temperatures in Leckler Creek consistently exceed state standards for Class A streams from late June through early September (CCD unpublished). Temperatures were recorded continuously on Mill Creek, just below Barrier Dam, from July 1955 through September 1956. During this period, temperatures ranged from 1.5° to 20.5°C. Maximum monthly temperatures exceeded the Class A state standard of 18.0°C during both the July and August monitoring periods and one of the September monitoring periods (Harza 1999a).

Water Quantity

Before dams were constructed on the river, the stream-flow pattern was characterized by high flows during winter, when peak, instantaneous flows occurred. Flows generally receded during late winter; with increasing flows during late spring and early summer due to snow melt. Flows receded through summer, although flow decline was moderated by glacial runoff. Lowest flows in the Cowlitz River occurred in the early fall. Flow regulation at the dams reduces flood-flow magnitudes and increases late-summer flows over historic levels. The EDT analysis states that flow and temperature characteristics during some salmonid life stages are enhanced due to flow regulation at hydroelectric projects. It also stated that conditions have improved for the intermediate host of the salmonid parasite, *Ceratomyxa shasta* under the regulated-flow regime (Mobrand Biometrics 1999).

The EDT analysis indicated that the lower mainstem Cowlitz River has not experienced water withdrawals above historical levels. It also indicated that flow has been slightly degraded (Mobrand Biometrics 1999). The Cowlitz Trout Hatchery on Blue Creek has an 18 cfs water right, but does not use the right (TAG). It is largely unknown whether there are significant water withdrawals from other tributaries.

Toe width flows were calculated for the following rivers and creeks in the Lower Cowlitz Subbasin; Leckler Creek, Olequa Creek, Lacamas Creek, Salmon Creek, Cedar Creek, and Mill Creek (see Table 32) (Caldwell et. al. 1999). Spot flow measurements for rivers and creeks in WRIA 26 are listed in Table 33. In comparing the optimal toe width flows of Table 32 with the spot flow measurements taken in the late summer and fall of 1998, it is apparent that Leckler, and Olequa creeks had flow levels on August 31 and October 3 that are far below optimal for spawning and rearing conditions. By November 10, the creeks still had too little water to be anywhere near optimal flows for spawning but are approaching optimal levels for juvenile salmonid and steelhead rearing.

Lacamas and Salmon Creeks were also well below optimal spawning and rearing flows when the spot flows were taken in August and October. Even by November 10, flow levels did not approach optimal levels for rearing in these streams. In Mill Creek the flow levels on November 10 were very low, but a little more suitable for rearing conditions than Lacamas and Salmon Creek. Flows were a little over 50% of optimal flow for rearing on this date in Mill Creek. All of these creeks in the subbasin have potentially significantly reduced fish production because of low flows.

Table 32: Toe-Width Flows for the Lower Cowlitz River Subbasin

Stream Name	**Tributary to**	**Average Toe Width (in feet)**	**Toe-Width Flow for Fish Spawning and Rearing (in cfs)**					
			Chinook Spawning	Coho Spawning	Chum Spawning	Steelhead Spawning	Steelhead Rearing	Salmon Rearing
Leckler Creek (@ Hazel Dell Rd)	Cowlitz River	8.3	18.8	8.8	18.8	18.0	3.3	2.9
Olequa Creek (@ Kollock Rd bridge)	Cowlitz River	54.3	192.6	103.0	192.6	159.5	47.7	43.8
Lacamas Creek (@ HWY 506 bridge)	Cowlitz River	42	140.1	73.6	140.1	118.4	33.1	30.2
Salmon Creek (@ Jackson Hwy)	Cowlitz River	59.8	217.1	116.9	217.1	178.4	54.7	50.3
Cedar Creek (@ 505 crossing)	Salmon Creek	26.8	80.2	40.9	80.2	70.3	17.5	15.8
Mill Creek (@ Cowlitz Salmon Hatchery)	Cowlitz River	29.8	91.5	46.9	91.5	79.5	20.3	18.4

Table 33: Spot Flow Measurements of Cowlitz River tributaries.

WRIA 26 Measured Flows (cfs)			
Date	8/31/98	10/1/98	11/10/98
Cedar Creek (@ Hwy 505 crossing)	0.2	0.5	5.8
Leckler Creek (@ Hazel Dell Rd)	0.4	O.5	3.0
Olequa Creek (@ Kollock Rd Bridge)	12.1	12.1	31.0
Lacamas Creek (@ HWY 506 Bridge)	3.3	4.4	7.6
Salmon Creek (@ Jackson Hwy)	0.9	2.8	14.0
Mill Creek (@ Cowlitz Salmon Hatchery)	2.7	3.0	10.0
Arkansas Creek (near Castlerock)	5.97	5.98	35.4

Adapted from Caldwell et. al. 1999

Biological Processes

The Conservation Commission is using the number of stocks meeting escapement goals as a surrogate measurement of nutrient levels within stream systems (see Habitat Rating Standards in Appendix B). Escapement for most anadromous stocks in the Cowlitz River is well below historic levels (WDF et. al. 1993; LCSCI 1998), and the lack of carcasses contributing nutrients to the systems may be limiting production within the subbasin.

Predation and competition of wild salmonids with hatchery fish are significant due to large, annual releases of sub-yearling and yearling juvenile hatchery fish from the Cowlitz Salmon and Trout Hatcheries located in this subbasin (Mobrand Biometrics 1999).

Historically, there was a diversity of fish pathogens in the Cowlitz River, but *Ceratomyxa shasta* is assumed to have been in low abundance. Currently, pathogens have greater impacts on salmonid survival due to large releases of hatchery fish, and because conditions have improved for the intermediate host of *C. shasta* under the regulated-flow regime (Mobrand Biometrics 1999).

Mayfield/Tilton Subbasin

This subbasin includes Mayfield Lake, the Tilton River system, and Winston Creek watershed. Some of the larger tributaries to the Tilton River are the North, South, East, and West Forks of the Tilton, Lake Creek, Nineteen Creek, and Connelly Creek.

Historical information for this area was collected from the Ecosystem Diagnosis and Treatment (EDT) analysis (Mobrand Biometrics 1999). Their summary statements about original habitat, circa 1820, were presented as assumptions, based in some cases on empirical observations, while in others (historic descriptions) are inferred from various sources identified and documented through the EDT process. Statements about changes in survival conditions are with respect to fall chinook, which was used as the diagnostic species.

Access

Barrier Dam and Mayfield Dam prevent the volitional passage of all anadromous fish to Mayfield Lake and the Tilton watershed. These dams are the major habitat limiting factor in this subbasin.

It is difficult to estimate the survival of smolts through Mayfield Lake, although recent radio-telemetry studies on coho and steelhead suggest that predation may significantly affect downstream migration success (Harza 1999a). There could be a number of reasons for the low number of fish that successfully navigated the reservoir. Some smolts may have reached the dam but were not recorded due to limitations of the telemetry equipment. Some may have survived, but did not find their way to the bypass facility. However, with success rates of 49 percent or below, it is likely that predation (Harza 1999a) or other habitat issues (water quality or inadequate flows to attract migrants) had a significant impact on smolt migration success.

Detailed culvert survey information on fish blockages is generally not available in the Winston Creek and Tilton River watersheds and passage conditions are largely unknown. The USFS (EA 1998), Murray Pacific (1998; 1996a; 1994; 1993), and TAG members reported the following observations.

- Winston Creek used to be inaccessible to anadromous fish due to a natural falls near the mouth (McIntosh 1995). The level of Mayfield Lake is currently above these falls, so anadromous fish in Mayfield Lake can now enter Winston Creek (TAG).
- Nearly two-thirds of the culverts in the Connelly Creek watershed are obstructed (Murray Pacific 1993).
- In the East Fork and South Fork Tilton rivers, 24 of 31 culverts were undersized to pass a 50-year peakflow with rain-on-snow enhancement. Most of the properly-sized culverts were in the South Fork Tilton and Coal Creek watersheds (Murray Pacific 1994).
- There are 16 road crossings on the West Fork Tilton River (EA 1998). It is not known how many culverts are fish passage barriers.

Floodplain Connectivity

There are 29.0 miles of stream-adjacent roads on anadromous streams in this subbasin (33 percent of the anadromous streams) (see Map 12a)(Lewis County GIS 2000). It is not known what effect they have on floodplain connectivity. Most of the smaller streams in this subbasin are naturally confined and have little, if any, floodplain habitat. The following statements are the only information available on the current condition of floodplain connectivity in this subbasin:

- The mainstem Tilton, below the West Fork confluence, is naturally unconfined and meanders. It becomes braided during times of high sediment supply. Above the confluence, the river is naturally confined (Murray Pacific 1998).
- In the West Fork area of the mainstem Tilton, portions of the highway and power line run within the 10-year floodplain. The railroad trestles are highly vulnerable to peakflow changes (Murray Pacific 1998).
- The Road 73 crossing on the North Fork Tilton is constricting the floodplain (EA 1998).
- Otter Creek, in the North Fork watershed, has a road crossing near the mouth that alters the channel during high flows (EA 1998).
- Connelly Creek has areas of rip-rap that restrict stream channel connection to the floodplain (Murray Pacific 1993).
- Heavy armoring exists throughout the anadromous zone on the East Fork Tilton (Murray Pacific 1993).

Bank Stability

Bank stability conditions in this subbasin are generally unknown, but most reaches in the Tilton watershed are sediment-transport reaches composed of large rock and bedrock; finer materials are transported downstream. As such, stream banks are inherently stable and resistant to erosion. Exceptions to this condition appear in the lower reach of the North Fork Tilton where it runs through easily-erodible glacial till and in the mainstem Tilton below the West Fork Tilton. Bank scouring and associated channel widening occurs in this reach (EA 1998). Bank stability is also poor in Otter and Tumble creeks (North Fork Tilton tributaries)(TAG). Most of Winston Creek has a moderate amount of bank instability due to high peak flows likely caused by an extreme amount of timber harvest in the basin (TAG).

Large Woody Debris

Historically, large wood in the Tilton watershed was contained within channels, and large log jams were present throughout the watershed (Mobrand Biometrics 1999). Channel cleaning and timber harvest in riparian zones have greatly reduced LWD and future LWD potential in the Tilton watershed (EA 1998). Debris torrents, dam-break floods, and larger peakflows have also reduced instream LWD. These conditions are primarily due to an increase in mass wasting, erosion, and runoff from harvested areas and roads (EA 1998). The following comments provide some information on LWD levels in specific stream systems:

- Winston Creek has only 3.2 pieces of LWD per mile in the lower 5.3-mile reach (Harza 1997). There is no data for Winston Creek above this reach.
- Portions of the mainstem Tilton River have fair to good LWD, based on Timber, Fish, and Wildlife criteria. There has been an increase in LWD since the 1937 surveys reported by Bryant (1949), likely due to bank erosion during the 1996 floods (Murray Pacific 1998).
- In Otter Creek, a North Fork Tilton tributary, there was no LWD observed on private lands. The U.S. Forest Service owns 50 percent of the land along this creek and maintains a high, LWD potential on its lands. It is assumed that LWD contribution to the stream channel from Forest Service lands is adequate (EA 1998).
- LWD potential is good in federal lands along Little Creek, a North Fork Tilton tributary, where 60 percent of the riparian zone is in large-tree structure. About 20 percent of the riparian zones on private land are harvested (EA 1998).
- Lower Winnie Creek, a tributary to the North Fork Tilton has a high LWD potential (EA 1998).
- A coniferous, old-growth stand exists in much of the riparian zone in the East Fork Tilton, in the reach between Slam Creek and the upper, Type-3 waters of the East Fork Tilton, and in Picture Creek. This area provides good LWD potential (Murray Pacific 1994). However, the TAG identified a lack of instream LWD as one of the two most important limiting factors in the East and South Fork rivers.
- According to Murray Pacific (1998) the lower West Fork Tilton River has "a fair amount of LWD."

Pool Frequency

Pool frequencies in this subbasin are generally considered to be “poor” and coincide with a lack of LWD. In streams with LWD, the number of pools was 15 times greater than in streams lacking LWD (EA 1998). Within the Tilton watershed, channel complexity has been simplified, so deep pool habitat and spawning gravel presence is low (EA 1998). Table 34 shows total and percent area of each stream habitat type for five streams in the subbasin.

Table 34: Total area and percent area of habitat types in each study stream.

Stream	Total Habitat Area (m^2)	% Pool	% Riffle	%Glide	%Cascade	% Step/Falls
Tilton River[1]	712,247	18.6	37.8	38.7	4.7	0.1
East Fork Tilton[2]	45,729	19.1	38.2	12.1	30.6	0
South Fork Tilton[3]	38,040	20.8	60.0	17.4	1.8	0
Lake Creek[4]	10,117	72.2	13.1	12.5	2.1	0
Winston Creek[5]	67,178	34.6	32.7	31.0	1.7	0

All surveys were conducted from the river mouth.
1 = 22.9 miles surveyed; 2 = 3.0 miles surveyed; 3 = 5.3 miles surveyed; 4 = 1.4 miles surveyed; 5 = 5.3 miles
Adapted from Harza 1997b

Of the surveyed streams, only Lake Creek is above the 50 percent required for a "good" percent-pool rating. The other streams are rated "poor" (less than 35 percent pool area).

While the surveyed reaches of the Tilton River had only 18.6 % pool habitat, Murray Pacific (1998) found that the mainstem Tilton in the West Fork area has abundant, deep pools that provide excellent coho summer-rearing habitat. In the East Fork Tilton, 41 percent of the pool depths exceeded 3 feet, although refuge cover was poor. In the West Fork Tilton from 1974 to 1996, mass wasting expanded gravel bars, and pool-riffle morphology developed in areas of increased sediment storage, reducing pool frequency, quality, and depth (Murray Pacific 1998).

Side-Channel Availability

Historically, the Tilton subbasin had highly-varied habitat conditions within constrained and unconstrained reaches. These conditions provided a mix of single and multiple channel areas with an abundance of key habitat for all freshwater life stages of salmonid species (Mobrand Biometrics 1999). There is little information on the current condition of side channels in this subbasin, and there are no comparisons to historical conditions.

Overflow channels exist on the mainstem Tilton River (TAG), but it is not known how many there are or the quality of the habitat they provide. Side channels and low-gradient tributaries are rare in the East Fork Tilton watershed. There is a general lack of low-velocity, rearing areas, and at least two meanders were cut off in the 1970s (Murray Pacific 1994). Some East Fork meanders have also been eliminated by debris flows (TAG). The West Fork Tilton has some side-channel rearing habitat (Harza 1997b). Winter rearing habitat is limited within Connelly Creek because pools are shallow and off-channel habitat rare (Murray Pacific 1996).

Substrate Fines

Historically, fine-sediment loading in the Tilton watershed is assumed to have been low (Mobrand Biometrics 1999). During the 1996 Harza stream habitat surveys, streambed substrate and embeddedness were assessed. Embeddedness is the measure of the degree that gravel and cobble are surrounded or covered with fine-grained sediment. This measure indicates the suitability of the substrate to provide a healthy environment for spawning and incubation of salmonids, as well as to provide areas for macroinvertebrate production. As embeddedness increases, the biotic productivity of a stream is thought to decrease (Harza 1997b; USFS 1993). Streams with low embeddedness (less than 35 percent) have the potential to support relatively high macroinvertebrate populations, so juvenile salmonid densities increase (Harza 1997b; Harkleroad 1993). Table 35 summarizes substrate type for several Tilton River tributaries.

Table 35: Dominant substrate type and percentage of habitat units with embedded substrates.

Stream	**Sand %**	**Gravel %**	**Cobble %**	**Small Boulder %**	**Large Boulder %**	**Bedrock %**	**Embedded Substrate %**
Tilton River[1]	9.6	35.3	42.4	3.4	1.6	7.6	26
East Fork Tilton[2]	14.7	66.8	16.5	0.3	0	1.8	9
South Fork Tilton[3]	15.1	43.7	38.9	1.1	0	1.3	85
Lake Creek[4]	11.6	62.4	24.5	1.6	0	0	63
Winston Creek[5]	3.8	36.2	44.2	9.9	1.4	4.6	53

Adapted from Harza, 1997b.
All surveys were conducted from the river mouth.
1=22.9 miles surveyed; 2=3.0 miles surveyed; 3=5.3 miles surveyed; 4=1.4 miles surveyed; 5=5.3 miles surveyed

Table 35 shows that more than half the habitat units in the South Fork Tilton, Lake Creek, and Winston Creek have greater than 35% embedded substrates (Harza 1997b), and approximately 85% of the surveyed substrates in the South Fork Tilton were embedded.

Fine sediments in Connelly Creek spawning habitat rose from 7% in 1993 to 18% in 1996. Embeddedness in 1996 was severe in most areas, and the surface layer was difficult to penetrate with a shovel. Approximately 30 mass-wasting features were identified in the Connelly Creek watershed. There has been an increase in the number of debris flows in the watershed that coincide with large storms and with logging activities in steeper areas of the basin (Murray Pacific 1996).

Fine sediments in the West Fork Tilton River are only a problem from the Coon Creek confluence to the mouth, where the 302 Road runs adjacent to the stream. High harvest levels create a high potential for debris flows in this watershed (Murray Pacific 1998). The West Fork Tilton and its three major tributaries, Coon, Snow, and Trout creeks all have high road densities of 3.6, 4.9, 4.3, and 3.9 miles per square mile, respectively (EA 1998).

The mainstem Tilton from Nineteen Creek to the falls has experienced mass wasting, beginning in 1974 and continuing to 1996, that has altered the channel morphology in several segments. Aggradation, braiding, and increased channel width have all been observed (Murray Pacific 1998). The TAG assumes there are excessive fine sediments in this reach.

Areas with no apparent fine-sediment problems are Coal Creek and the East Fork Tilton River (Murray Pacific 1994). Stream energy appears sufficient to keep the streambeds clean of sediment, and extensive sediment sampling has shown that fine-sediment accumulation was less than 8 percent. While fine sediment may be low in these stream systems, high stream energy has flushed spawning gravels out of the systems too, leaving generally unsuitably-large substrates consisting of material greater than 6 inches. Boulders are the dominant substrate for the first 6.8 miles of the East Fork. It is thought that these conditions are caused by a lack of sediment-trapping features (Murray Pacific 1994).

The North Fork Tilton tributaries are generally characterized by recent and extensive timber harvest, high road densities, mass wasting, and stream adjacent roads. This is also a high-energy system, with mostly source and transport reaches; therefore, fine sediments are generally washed downstream (EA 1998).

With 4.88 miles of roads per square mile and 29 miles of stream-adjacent roads in the Tilton Subbasin, fine sediment delivery to stream channels is likely excessive (see substrate fines in Habitat Rating Standards in Appendix B).

Riparian Conditions

Historically, the riparian zone in the Tilton watershed was forested primarily by large, coniferous species, with deciduous species along unconstrained stream reaches (Mobrand Biometrics 1999). Currently, riparian conditions in this subbasin are generally poor. Even though there are areas with adequate stream shading, the conifer component is typically low. In general, the riparian forest in the Tilton watershed is composed of relatively young conifers and/or deciduous trees with very little large-tree structure (Murray Pacific 1994 and 1996; EA 1998).

Map 11a illustrates riparian conditions along streams in the Mayfield/Tilton Subbasin, and Table 36 summarizes the data (data from Lunetta et. al. 1997; Lewis County GIS 2000). Over 97% of the riparian corridors in the subbasin have either poor or unknown (early seral) riparian conditions. The few areas with good conditions occur in the upper reaches of the North, East, and West Forks of the Tilton and Winston Creek.

Table 36: Riparian Conditions in Mayfield Tilton Subbasin

Basin Name	**Riparian Condition**	**Length (miles)**	**Percentage**
MAYFIELD-TILTON	Good	53.48	12.8
	Unknown	196.12	46.9
	Poor	168.38	40.3
Total		*417.98*	*100.0*

Lunetta et. al. 1997; Lewis County GIS 2000.

The following statements refer to more specific riparian conditions in this subbasin:

- Overall, timber stands in the East and South Fork Tilton Rivers have dense, mostly mature trees. Dense, mature stands of deciduous trees dominant the East Fork, from the mouth to the South Fork confluence. Then young, mixed, and deciduous trees dominate. The north side slope in this reach is steep and has been harvested, giving it a low LWD recruitment potential (Murray Pacific 1994).

- A coniferous, old-growth stand exists in much of the riparian zone in the upper East Fork Tilton between Slam Creek and the upper, Type-3 waters of the East Fork Tilton. Picture Creek, southeast of Slam Creek, is also in good condition (Murray Pacific 1994).
- On the South Fork Tilton, riparian areas are mostly mature, deciduous stands. It is likely that this is a natural condition because of the broad banks and the possible high water tables. There is about a 1.5-mile area in the mid-South Fork Tilton without adequate shading (Murray Pacific 1994).
- Riparian plants provide good stream shading in the West Fork Tilton (Harza 1997b).
- In Trout Creek (West Fork Tilton), medium- to large-sized hardwoods provide a full-channel canopy (Murray Pacific 1998).

Table 37 shows selected reaches in the Tilton watershed that were surveyed for stream cover provided by vegetation (Harza 1997b). Greater than 60 % of all the surveyed reaches had less than 20% canopy cover, and along the surveyed reaches of the East Fork Tilton 89 % of the riparian areas had less than 20% canopy cover. Without adequate canopy cover, riparian function is likely impaired. It appears that stream temperatures have increased in many streams systems within the subbasin, often due to the lack of riparian shading (see the following Water Quality section).

Table 37: Percentage of habitat units assigned each percent-cover category

Stream	0 – 5 %	6 – 20 %	21 – 40 %	> 40 %
Tilton River	28	43	16	13
East Fork Tilton	8	81	11	0
South Fork Tilton	44	35	16	5
Lake Creek	21	40	33	6

Adapted from Harza 1997b.

Water Quality

Historically, water temperatures in the Tilton watershed remained cool throughout the summer (Mobrand Biometrics 1999). Currently, summer temperatures are above 14°C, considered to be optimal for salmonid habitat, due to a lack of stream shading (Murray Pacific 1994; 1996; 1998) and low summer flows (Murray Pacific 1994). Dissolved oxygen measurements are not above state standards, with the exception of deep-water measurements in Mayfield Lake. Turbidity is elevated in the Tilton watershed and in the Tilton arm of Mayfield Lake during storm events (TAG). The following statements summarize temperature measurements made throughout the subbasin:

- Thermal stratification occurs during the summer in Mayfield Lake near the dam, where the thermocline is at 10 feet or less. Daily mean temperatures during summer at 3-, 6- and 10-foot depths were above 19, 15, and 12°C, respectively. Temperatures measured near Mossyrock Hatchery and Ike Kinswa State Park were above 22°C to a depth of 3 feet.

- Winston Creek temperatures were measured from 1997 to 1999. The maximum, 7-day average temperature for these years was 20.9°C, and the maximum, daily-maximum temperature was 23.2°C (Harza 1999b).
- Temperatures for the mainstem Tilton, just upstream of Bear Canyon Creek, were measured from 1997 to 1999. The maximum, 7-day average temperature for these years was 22.4°C, and the maximum, daily-maximum temperature was 24.8°C in 1998 (Harza 1999b).
- The mainstem Tilton, just upstream of the West Fork confluence, had temperatures that exceeded 19°C (Murray Pacific 1998).
- No temperature data is available on the North Fork Tilton, but the unconfined nature of the channel and harvested riparian zones indicate that the temperature may exceed 16°C (Murray Pacific 1998).
- Tumble Creek (North Fork Tilton) had 5 days in a one-year period that exceeded 16°C (Murray Pacific 1998).
- Peak stream temperatures in Connelly Creek have exceeded acceptable levels for fish habitat in the four years of temperature monitoring. Readings occasionally exceeded 22°C in the lower reach. Peak temperatures and stream shading data suggest that shade is the dominant factor influencing peak stream temperatures in this watershed (Murray Pacific 1996).
- Continuous temperature monitoring in the East and South forks during the summer exceeded 16°C for 35 hours and 13 hours, respectively (Murray Pacific 1994). Harza habitat studies (1997b) showed a maximum reading of 17°C.
- Slam Creek had the highest instantaneous temperature in the East Fork watershed at 21°C. This creek experienced a wildfire in 1988 that eliminated riparian shade (Murray Pacific 1994).
- Temperatures collected in July and September 1993 in the South Fork Tilton ranged from 10.0 to 13.6°C (Murray Pacific 1994). Harza habitat surveys (1997b) reported 17.8°C in 1993.
- The West Fork Tilton has temperatures significantly above what would be expected (19°C.), due to solar radiation in the headwater lake area (Murray Pacific 1998).
- Snow and Coon creeks (West Fork Tilton) lack riparian shade for long stretches. Temperatures exceeded 19°C in Coon Creek (Murray Pacific 1998).
- Trout Creek (West Fork Tilton) only had one day in 1994 with a recorded temperature greater than 16°C (Murray Pacific 1998).
- Nineteen Creek has had recorded temperatures above 16°C in each of the 3 years of monitoring. This creek has a lack of riparian shading (Murray Pacific 1998).

The following statements summarize water quality measurements and observations, other than temperature, that have been made throughout the subbasin:

- Dissolved oxygen (DO) measurements in Mayfield Lake indicate that near the bottom just upstream of the dam, DO concentrations drop below 6 mg/L prior to fall overturn. DO concentrations also drop below 6 mg/L in deep water in the Tilton River arm of Mayfield Lake during mid-summer (Harza 1999b).

- The turbidity in Mayfield Lake rises to 27 NTU and remains above the state standard of 5 NTU for a longer period than turbidity levels in Riffe Lake (Harza 1999). The TAG thought that high turbidity from the Tilton River in the winter adds to the turbidity of Mayfield Lake.
- The minimum DO measurement in the mainstem Tilton River was 8.0 mg/L (Harza, 1999).
- The TAG expressed concern that the lumber mill on Lake Creek may be discharging potentially harmful runoff directly into the creek.
- Turbidity in Connelly Creek typically varies seasonally and generally ranges between 0.3 and 20 NTU, with the average of about 1 NTU. However, one-day spikes have reached as high as 45 NTU (Murray Pacific 1993).

Water Quantity

Historically, the mainstem Cowlitz River had a stream-flow pattern characterized by high flows during winter, when peak, instantaneous flows occurred. The flow generally receded during late winter; with increasing flows in late spring and early summer due to snow melt. Flows receded through summer, although they were moderated by glacial runoff. Lowest flows occurred in early fall (Mobrand Biometrics 1999). Currently, extremes in high and low flows exist throughout the watershed and are probably due to extensive harvesting (Mobrand Biometrics 1999).

The following statements summarize high and low flow problems in the Tilton/Mayfield subbasin:

- During rainstorm events, Winston Creek responds very quickly with high flows, likely due to extensive timber harvest within the watershed (TAG).
- TAG members felt that over-winter survival in the Tilton River watershed is below expectations due to elevated peak flows. Elevated peak flows, especially when combined with the lack of pools, off-channel habitat, and instream structure, often flush juveniles out of the Tilton watershed (TAG).
- The mainstem Tilton River has limited spawning capacity due to lack of spawning gravel. Elevated peak flows and lack of LWD, transport spawning gravels out of the river (TAG).
- Small, fully-harvested, side-wall drainages in the North Fork Tilton have high potential for altered flows. It is unknown how flow regimes in the North Fork have been altered by management practices (EA 1998).
- Wallanding Creek (North Fork Tilton) has high road densities (5.8 miles/square mile) and past clearcuts that have created a high potential for an altered flow regime. However, most harvest units are now in the 21 to 40 year age class and the WAU is likely recovering (EA 1998).
- Washington State Watershed Analysis criteria state that greater than a 10 percent peakflow increase indicates possible downstream flood damage and scour damage to fish-spawning areas. The average potential peakflow increase due to harvesting in Connelly Creek is approximately 10 percent (Murray Pacific 1996) and in Lake Creek, it is as great as 22 percent (Murray Pacific 1994). On the average, potential

peakflow increases from harvesting are estimated at 20 percent in the East Fork and 17 percent in the South Fork (Murray Pacific 1994). Peak flow increases are considered to be major limiting factors in the East and South Forks of the Tilton (TAG).

- Dam-break floods are the most damaging physical process to aquatic resources in the Connelly Creek watershed. They remove almost all dispersed woody debris from within the channel, thereby reducing pool habitat and fish habitat diversity. There have been at least three dam-break floods in Connelly Creek since the 1960s, and all were associated with landslides originating at or near logging roads and from within clearcuts (Murray Pacific 1993).
- Low summer flows in the North, South, East, and West forks of the Tilton cause severe degradation of habitat with an average low-flow depth of less than 1 foot (Harza 1997a).
- In the West Fork Tilton, current vegetative age-classes will likely cause only small increase in peakflow. Increases in flood stage and bed mobility under current conditions appear to be almost undetectable and are insufficient to cause substantial channel changes in the high-roughness, mountain channel (Murray Pacific 1998).
- Most harvest units in Coon Creek (West Fork Tilton) have recovered hydrologically (Murray Pacific 1998).

Biological Processes

The Conservation Commission is using the number of stocks meeting escapement goals as a surrogate measurement of nutrient levels within stream systems (see Appendix B). Escapement goals do not exist for the Tilton system, but a comparison can be made between past and present escapement numbers. The EDT analysis estimated returns of 5,400 fall chinook and 1,520 winter steelhead in 1820, for a minimum escapement of 6,920 (coho and spring chinook estimates were not published)(Mobrand Biometrics 1999). Approximately 7,800 adult male and female coho were released into the Tilton River in 1999. TAG members felt that nutrients from salmon carcasses were being widely distributed in this subbasin, and that they were providing adequate levels of nutrient enhancement.

In the Cowlitz River, the majority of fish-on-salmonid predation occurs predominantly in Mayfield Lake (Harza 1999a; Harza 1997b). Northern pikeminnow, formerly known as the northern squawfish, are known to prey on young salmonids and are abundant in the Tilton arm of Mayfield Lake with an estimated population of 2,497 (Harza 2000). Northern pikeminnow prefer low water velocities, so reservoir construction has increased their preferred habitat (Harza 1999a).

A new Atlantic salmon farm has been permitted in the mainstem Tilton area between Mayfield Lake and the North Fork confluence. There is also an existing Atlantic salmon farm on Cinnebar Creek (a Tilton River tributary) (TAG). These operations increase the chances of disease transmission to wild fish in the subbasin.

Riffe Lake Subbasin:

Access

Fish passage is the most significant habitat limiting factor in the Riffe Lake subbasin. The 606-foot-high Mossyrock Dam was constructed between 1964 and 1968. Due to its height, the dam was not equipped with either adult or juvenile passage facilities (Harza 1999). Past attempts to develop juvenile fish passage at Mossyrock dam were unsuccessful due to a combination of factors including reservoir size, water temperature, and the limitation of collection technology available at the time (Harza 1999c). The collection of downstream migrants from Riffe Lake was discontinued in 1974 (Harza 1996).

Successful juvenile migration through Riffe Lake appears to be a significant problem (Harza 2000; TAG). During a 1999 Riffe Lake smolt behavior study (Harza 2000) 339 steelhead smolts, 145 coho smolts, and 102 chinook smolts with radio tags were released upstream of Cowlitz Falls Dam. aRiviere 2000, personal comm.).

Table 38 details the detection rates of radio-tagged-smolts (RTS) as they either passed through the Cowlitz Falls turbines or were captured and re-released into the Cowlitz Falls tailrace, as well as travel times, and the percentage of steelhead smolts that made it to Mossyrock Dam.

Approximately 63% of the steelhead smolts that were detected at Cowlitz Falls Dam successfully migrated through Riffe Lake to reach Mossyrock Dam. Migration success through Riffe Lake for coho and chinook smolts was a very different story. There were difficulties encountered with the radio tags that limited the number of coho and chinook smolts that were tracked. None of the 13 coho smolts and 17 chinook smolts that passed through Cowlitz Falls Dam and were detected in the tailrace were subsequently detected at Mossyrock Dam (Harza 2000). Even if migration success could somehow be enhanced within Riffe Lake, studies found that a “Merwin trap” located just upstream of Mossyrock Dam was not efficient in collecting migrating salmonid juveniles (Harza 2000).

Considering the problems with juvenile migration through Riffe Lake and the ineffective collection of juveniles at Mossyrock Dam, successful capture and transport of downstream migrants at the Cowlitz Falls facility, or at least before smolts enter Riffe Lake, is an extremely important element of any successful reintroduction efforts in the upper Cowlitz basin.

Currently, it is uncertain whether the Cowlitz Falls Fish Collection Facility (CFFCF) alone can collect a sufficient number of juveniles to maintain self-sustaining runs of anadromous salmonids in the upper Cowlitz Basin (Harza 2000). The most recent collection efficiencies from CFFCF are from the U.S. Geological Survey radio tagging work conducted in 1999. Table 39 shows the smolt collection efficiency (LaRiviere 2000, personal comm.).

Table 38: Smolt migration study through Cowlitz Falls Dam and Riffe Lake

	RTS* collected and released from CFFCF into the tailrace	RTS* released into Lake Scanewa that passed Cowlitz Falls Dam into the tailrace	All RTS* in Cowlitz Falls tailrace
Number in tailrace	112	187	299
Number recorded at Mossyrock Dam	68	119	187
% recorded at Mossyrock	61%	64%	63%
Average days of travel	4.2	4.3	4.3
Standard deviation	2.2	2.8	2.5
Median days of travel	3.6	3.5	3.5

RTS* (Radio Tagged Smolts)
Adapted from Harza 1999a

Table 39: Smolt Collection Efficiency at the Cowlitz Falls Fish Collection Facility

Species	Collection Efficiency
Spring chinook	26%
Coho	42%
Steelhead	47 - 53%

Mark LaRiviere (Personal communication 5/1/00)

Mossyrock Dam also blocks anadromous passage into various tributaries of the Cowlitz. Rainey Creek is the only tributary to Riffe Lake with a substantial amount of potential habitat for anadromous salmonids (Map 7 in Appendix A). Bryant (1949) estimated that there was suitable habitat within Rainey Creek to support 1,300 pairs of salmon. Meekin (1961) estimated that one three-mile stretch of Rainey Creek could support an estimated 200 pairs of silvers (coho salmon). TAG members and Kray (1957) noted that Rainey Creek was historically one of the better steelhead streams in the upper Cowlitz basin.

The Kosmos Watershed Analysis (Murray Pacific 1996b) found no major upstream migration concerns to fisheries within the WAU, which includes Rainey Creek and all its tributaries. Few logging roads cross fish-bearing waters in the WAU; those that do cross are bridged (Murray Pacific 1996b). However, fish passage problems may arise within Rainey, Stiltner, and Lunch Creeks due to subterranean flows through excessive sediment deposits (Murray Pacific 1996b).

Floodplain Connectivity:

The construction of Mossyrock Dam flooded 23.5 miles of what was historically a largely unconstrained, braided channel within an alluviated valley (Mobrand Biometrics 1999). Before the dams, the main channel provided abundant key habitat for all freshwater life stages of salmonid species present in the subbasin (Mobrand Biometrics 1999).

Rainey Creek has been constrained to the easternmost portion of its alluvial fan by construction of a dike (Murray Pacific 1996b). Stream cleaning and channelization has occurred in the past on the alluvial fans of several Rainey Creek tributaries through attempts to prevent flood damage and loss of property (Murray Pacific 1996b).

Bank Stability

In general, the TAG rated bank stability along Riffe Lake as good. Channel stability within Rainey Creek and its tributaries on the other hand has been impacted by a number of natural and anthropogenic disturbances. Significant changes in channel character have occurred following a total of 210 slides between 1937 and 1996 (Murray Pacific 1996b). Forestry activities were associated with approximately 80% of the inventoried landslides. Two major floods in 1995 and 1996 led to numerous debris torrents and inner gorge failures so that the channels avulsed and widened on both Rainey and Stiltner Creek alluvial fans (Murray Pacific 1996b).

Both TAG members and the Kosmos Watershed Analysis (Murray Pacific 1996b) noted that several areas of bank instability are associated with logging and grazing that has reduced or eliminated riparian vegetation.

Large Woody Debris

Cowlitz Falls Dam passes most LWD over the dam into Riffe Lake. TAG members noted that the LWD deposited in Riffe Lake could provide an excellent source of LWD for projects in the upper Cowlitz subbasin.

Similar to most stream systems in the Pacific Northwest, Rainey Creek and its tributaries also have low levels of functioning LWD. Approximately 93% of the fish-bearing channels and 87% of the Type 4 channels that would be responsive to LWD inputs contain below-target levels of LWD (Murray Pacific 1996b). The number of pieces of functional LWD was low in almost all segments surveyed. Of the 19 surveyed reaches in the Rainey Creek watershed; 13 reaches had fewer than one piece of functional LWD/channel width, 6 reaches had between one and two pieces/channel width, and none had greater than two pieces/channel width (Murray Pacific 1996b).

It may be some time before riparian forests within Rainey Creek watershed provide an adequate supply of LWD to the channels. Poor riparian conditions are found almost throughout the Rainey Creek drainage (Murray Pacific 1996b). Riparian forests along fish-bearing streams in the Rainey Creek watershed are primarily (68%) composed of small and medium-sized hardwoods. Near term LWD recruitment is "high" on only three percent of the fish-bearding streams and 19% of the Type 4 streams in the watershed (Murray Pacific 1996b).

Pool Frequency

Riffe Lake is essentially on large pool. When filled to capacity, the Lake reaches almost to the Cowlitz Falls Dam. The level of the lake fluctuates considerably as Riffe Lake is drawn down during the fall to provide storage for winter flood flows. The draw-down rarely exceeds 70 feet (Harza 1999c). The presence of the reservoir downstream may provide some refuge for fish displaced from tributary streams by high flows (Murray Pacific 1996). However, conditions within Riffe Lake are generally not favorable to salmonid growth and survival.

Swofford Pond is a 240-acre man made lake created as a steelhead mitigation facility in the late 1960's (Harza 1999a). After many years of attempting to raise steelhead, water conditions proved to be unsuitable, and attempts were abandoned in 1983. The pond is currently managed for warm water recreational fisheries (Harza 1999c).

The amount of pool habitat within Rainey Creek watershed (WAU) was rated as fair to good in only three reaches: South Fork Rainey, Lower Steffen, and Lunch Creeks (Murray Pacific 1996b). Pool quality varied throughout the watershed. Pools in larger streams (mainstem Rainey, lower Steffen, and South Fork Rainey) were relatively deep at low flows and cover provided by wood or overhanging banks was fair in most of the reaches where the parameter was measured (Murray Pacific 1996b).

Pools were typically controlled by either LWD or bedforms (including bedrock). The low pool frequency can be explained in most areas by the lack of LWD (Murray Pacific 1996b). Of the 110 pools where the formative element was recorded during the 1995 surveys, 55 were associated with LWD. Bedrock, boulders, and scour on the outside of meander bends formed the remaining pools (Murray Pacific 1996b).

Side Channel Availability

The construction of Mossyrock Dam flooded 23.5 miles of what was historically a largely unconstrained, braided channel within an alluviated valley (Mobrand Biometrics 1999). Before the dams, the main channel provided abundant key habitat for all freshwater life stages of salmonid species present in the subbasin (Mobrand Biometrics 1999).

The lower gradient channels within the Rainey Creek valley bottom tend to be incised and offer little off-channel or backwater habitat (Murray Pacific 1996b). The presence of the reservoir downstream may provide some refuge for fish displaced from tributary streams by high flows (Murray Pacific 1996b).

Substrate Fines

The majority of the spawning habitat on the Kosmos WAU (Rainey Creek and its tributaries) is located in the valley bottom segments of Rainey Creek and tributaries crossing the Rainey Creek floodplain (Murray Pacific 1996b). These low-gradient reaches contain a diverse substrate ranging from cobble to sand. Fish habitat surveys conducted for the Kosmos Watershed Analysis (Murray Pacific 1996b) measured fine sediments levels (<0.85mm) at a number of sites within the WAU where salmonid spawning might be anticipated. Fine sediment levels ranged from 0.3 percent to 24 percent. Table 40 lists the percent of fine sediment found in some of the potential spawning sites and the gravel quality rating (Murray Pacific 1996b).

Table 40: Substrate Conditions within Rainey Creek and various Tributaries

Stream location	% Fine Sediment	Gravel Quality Rating
Rainey RM 0.0	0.3%	Good
Rainey RM 1.6	16%	Fair
Rainey RM 3.2	12%	Fair
Rainey RM 4.2	16%	Fair
Steffen RM 0.5	20%	Poor
Lunch RM 0.3	20%	Poor
Stiltner RM 0.8	21%	Poor

Adapted from Murray Pacific 1996

In the LFA habitat rating standards, road densities are used as a surrogate to measure excessive fine sediment inputs to stream systems (see Appendix B). Using the LFA standards, road densities above 3.0 miles of road/square mile likely increase fine sediment inputs to the point that substrates have unacceptable levels of fines. With 145.7 miles of roads within an area of 472.2 square miles, road densities within the Riffe Lake subbasin are approximately 3.24 miles of road/square mile (Lewis County GIS 2000).

Riparian Conditions

Other than "recreation and project operation lands" around Mossyrock Dam, Mossyrock Park, and Taidnapam Park, almost the entire fringe around Riffe Lake is managed as wildlife lands by the WDFW with funding from Tacoma Power (Harza 1999c).

Riparian forests along fish-bearing streams within the Rainey Creek watershed are primarily (68%) composed of small and medium-sized hardwoods (Murray Pacific 1996b). The TAG also noted that riparian conditions are generally poor along Rainey Creek and its tributaries. The Kosmos Watershed Analysis (Murray Pacific 1996b) attributes the prevalence of hardwood stands to both natural and human factors. Wetland soils are widespread in the low-gradient valleys of Rainey Creek and its South Fork, and red alder and other hardwoods often dominate such soils. Additionally, many of these lowland areas have been converted to agricultural uses, and hardwood trees have proliferated in these disturbed areas. Logging in the early part of the century also removed conifers from most of the watershed, often without replanting (Murray Pacific 1996b). The net result of these factors is that riparian conditions are generally poor throughout the Rainey Creek watershed.

Map 11a in Appendix A illustrates the extent of the impacts to the riparian cover in the subbasin (data from Lunetta et. al. 1997). Table 41 summarizes Lunetta et. al. (1997) riparian cover data for the Riffe Lake subbasin. Only 17.4 percent of the subbasin has "good" riparian conditions (>70% late- and mid-seral stage conifer cover)(Lewis County GIS 2000). The majority of riparian habitat within the Rainey Creek watershed is either the unknown (early seral stage) or poor category. In some cases the streams are adequately shaded, but most areas do not have an adequate coniferous component or buffer width.

Table 41: Riparian Conditions in Riffe Lake Subbasin

Basin Name	Riparian Condition	Length (miles)	Percentage
RIFFE LAKE	Good	26.64	17.4
	Unknown	81.39	53.3
	Poor	44.68	29.3
Totals		*152.71*	*100.0*

Lunetta et. al. 1997; Lewis County GIS 2000

Water Quality

Water quality may also be a significant factor limiting salmonid production within Riffe Lake. Water temperatures at the surface of Riffe Lake exceeded the standards established for the LFA (see Appendix B) for migration and rearing during all three years of monitoring (Harza 2000). Temperatures during the summer and early fall of 1997 and 1998 at 10 meters also exceeded standards for migration and rearing. In 1998, temperatures even down to 20 meters would be considered “poor” by LFA standards (Harza 2000).

Table 42 provides water temperature data for selected sites within the Riffe Lake subbasin. Water temperatures within the Rainey Creek watershed are generally below levels that would negatively impact fish growth and metabolism. Peak water temperature data collected from 27 observations within the watershed between 1991 and 1995 ranged between 10.8 and 19.4°C (Murray Pacific 1996b). Murray Pacific (1996b) found that water temperatures exceeded state temperature criteria at 75% of the sites where riparian shading was below target levels. Where riparian shading met target levels only 43 %of the sites have had temperature measurements that exceeded state standards (Murray Pacific 1996b).

Table 42: Value of maximum daily and maximum 7-day maximum temperatures (°C) for 1997-1999

	Maximum Daily Temp. (°C)				Max. 7-day average max. temperature			
Site	**1997**	**1998**	**1999**	**1997-1999**	**1997**	**1998**	**1999**	**1997-1999**
COKOS*	16.8	18.8	15.4	18.8	16.3	18.1	15.1	18.1
MOSPH*	12.4	13.5	11.9	13.5	11.6	12.2	11.9	12.2
RAINT*	14.2	14.6	***	14.6	13.5	14.2	***	14.2

COKOS=Cowlitz River near Kosmos
MOSPH=Just Below Mossyrock Dam
RAINT= Rainey Creek at Glenoma Trout Farm
Adapted from Harza 1999a

Dissolved oxygen (DO) concentrations were also measured for the same monitoring sites. Riffe Lake DO concentrations remained above 10 mg/L throughout the water column between January and June. As summer progresses and water temperature increase, DO concentrations also decrease, particularly near the bottom (Harza 2000). DO concentrations of less than 6.5 mg/L were measured near the bottom during November 1997 and 1998, December 1998, and September 1999 (Harza 2000). DO concentrations from 6-8 mg/L are considered fair for migration and rearing by LFA standards (see Appendix B).

Turbidity was also monitored within a number of sites on the Cowlitz River, on three tributaries, and the lower reservoirs between 1997 and 1999. The highest measured turbidity (37 NTU) for all the monitored sites occurred at the Rainey Creek site in January 1999. This reading also coincided with the highest recorded Total Suspended Solids (TSS) reading (66 mg/L) measured in the any of the basins during the monitoring period. However, turbidity measurements in the Winston Creek basin and the Tilton River were generally higher than found in Rainey Creek and the highest turbidity levels measured in Rainey Creek for the rest of the monitoring period were only approximately 2 or 3 NTU (Harza 2000).

Swofford Pond turbidity measurements were relatively high during the summer months and were stable at relatively low levels during the remainder of the year, with an overall range of 0.8 to 18 NTU. Three measurements exceeded 10 NTU, coinciding with three of the four highest measured phytoplankton densities measured (Harza 2000). Turbidity measurements in Riffe Lake near the dam reached 10 mg/L only in February 1997 (Harza 2000). Turbidities above 5 NTU are rare in the surface waters of Riffe Lake, only occurring during periods of weak to no thermal stratification and when the reservoir was drawn down to 745 feet (Harza 1999c). TAG members noted that in general turbidity levels within Riffe Lake were considerably lower than found in Mayfield Lake.

Water Quantity

Flow regimes have been significantly altered by the operation of Mossyrock Dam. At its normal maximum pool elevation of 778.5 feet, Riffe Lake is approximately 23.5 miles long and two miles wide. The level of the lake fluctuates considerably as Riffe Lake is drawn down during the fall to provide storage for winter flood flows (Harza 1999c). The draw-down rarely exceeds 70 feet (Harza 1999c). Groundwater levels in the vicinity of Riffe Lake are lower when the reservoir is lowered, likely altering hydrology in the lower portions of tributaries like Rainey Creek (Harza 1999c).

Extreme summer low flows occur where Rainey, Stiltner, and Philips Creeks traverse the upper portion of the alluvial fan (Murray Pacific 1996b). Long reaches dry up during the summer and reduce the amount of low-gradient habitat available to fish. Isolated pools may remain but are likely inferior rearing locations due to water quality, temperature, and predation concerns (Murray Pacific 1996b). TAG members noted that Lunch Creek also has low flow problems during summer months.

A private hatchery in Glenoma has water rights to 50% of the Rainey Creek flow and 100% of the flow of an unnamed creek entering Rainey Creek from the south at approximately RM 4 (Murray Pacific 1996b).

Biological Processes

Scattered Eurasian milfoil plants have been discovered in Riffe Lake. There are noxious and wetland weed management plans in place to address invasions of various species including Eurasian milfoil and purple loosestrife (*Lythrum salicaria*)(Harza 1999c).

Anadromous salmonids are not presently released into Riffe Lake, and there are no plans for future releases (TAG). Since 1994, chinook and coho salmon, and steelhead have been planted in the upper Cowlitz River watershed above Cowlitz Falls Dam as part of the reintroduction program (Harza 1999). It is likely that a large number of these fish have been passed through or spilled over the Cowlitz Falls Dam into Riffe Lake (Harza 1999c). However, the number of fish returning to the Riffe Lake subbasin and the nutrient inputs from their carcasses is well below historic levels for this subbasin of the Cowlitz River.

Cispus Subbasin

Historically, the Cispus subbasin contained highly varied habitat conditions, and provided key habitat for all freshwater life stages of salmonid species. The subbasin was forested primarily by large, coniferous species and contained abundant large wood within stream channels. Large log jams were present throughout the watershed. Water temperatures were cool throughout the summer and moderate during the winter. Fine sediment loading was low (Mobrand Biometrics 1999).

Currently, the system of dams blocks all natural upstream salmonid migration and greatly inhibits natural downstream migration. Downstream migrants are captured at the Cowlitz Falls Dam and transported below the dams. The reservoir, Lake Scanewa, has inundated the lower reaches of the Cispus River and Copper Canyon Creek, increasing predation and reducing key habitat for spawning, incubation, and fry colonization (Mobrand Biometrics 1999).

In the Cispus subbasin, there are small to moderate losses of key habitat for most salmonid life stages. Survival conditions are moderately worsened from historic conditions, mainly due to increased fine sediment loading, increased channel and bed instability, and loss of habitat diversity in some reaches. Causes of habitat change are due to extensive and intensive forest-harvest practices that have resulted in the removal of large wood from streams, severe loading of fine sediment, large landslides in some areas, and alteration of flow-runoff patterns (Mobrand Biometrics 1999). A Forest Service watershed analysis states that most of the problems affecting fish habitat in the Cispus subbasin are related to timber management and associated road construction (USFS 1996b).

Access

Barrier, Mayfield, Mossyrock, and Cowlitz Falls dams on the Cowlitz River form complete barriers to volitional upstream passage of salmonids. Coho, winter steelhead, and coastal cutthroat have been trapped below Mayfield Dam and hauled above the Cowlitz Falls Dam as part of an anadromous reintroduction effort. Downstream passage is achieved by trapping downstream migrants at the fish-collection facility at the Cowlitz Falls Dam and hauling them below Barrier Dam. Passage also occurs through the turbines and when water is spilled through the dam (Mobrand Biometrics 1999); however, studies have shown that few juveniles, either steelhead or coho, successfully migrate downstream through Riffe Lake to Mossyrock Dam. The success of reintroduction efforts in the Cispus Subbasin is dependent upon the successful operation of the Cowlitz Falls Fish Collection Facility.

Only one blocking culvert was identified within the Cispus Subbasin. It is located near the end of Woods Creek, and blocks approximately 1 mile of potential habitat. However, the Forest Service and Lewis and Skamania Counties have not completed comprehensive culvert surveys of the entire subbasin.

Other anadromous, fish-passage problems in the Cispus subbasin are due to subsurface flows in tributaries to the Cispus River including:

- Copper Canyon Creek has subsurface flow near its mouth for 300 feet, probably caused by aggradation of the channel. Historically, this creek flowed into the Cispus and may have been used for coho rearing habitat and chinook spawning at the mouth (USFS 1996a).
- Crystal Creek flows subsurface during low flows from the mouth to RM 1.
- The Camp Creek headwaters and lower reaches are currently flowing subsurface. In some water years it flows throughout the year (TAG).

Floodplain Connectivity

The USFS states that there are significant data gaps in floodplain information within the Cispus subbasin (USFS 1996b). In general, connectivity is reduced in the subbasin by stream-adjacent roads and channelization. Wetlands and off-channel areas have been altered to maintain the Cispus River and larger tributaries in preferred channels, and roads isolate the river from old flood channels (USFS 1996b) (see Map 12b). There are 13.9 miles of stream-adjacent roads on anadromous streams in this subbasin (21 percent of the anadromous streams)(Lewis County GIS, 2000). On the mainstem Cispus, between Quartz and Iron Creek, there are stream-adjacent roads on both sides of river, and channelization efforts have reduced habitat complexity (USFS 1996a). Between Iron Creek and the North Fork Cispus, roads are influencing the Cispus meanders. Agricultural practices have also decreased connectivity in the subbasin (USFS 1996b).

The 1996 flood damaged roads located within floodplain in lower and middle Iron Creek (USFS 1996a). As a result, the USFS plans to decommission 4 1/4 miles of stream-adjacent roads. They will leave a small stretch of road within the floodplain (TAG). The Camp Creek alluvial fan is migrating, and this migration is constrained by the 23 Road (USFS 1996b).

The mouth of Yellowjacket Creek has been modified by channelization and timber salvage, which has reduced habitat complexity. The creek is confined by the 28 Road and by efforts to maintain the preferred channel. Yellowjacket Creek reclaimed two artificial ponds in the 1996 flood. The upper watershed has had major alterations of its floodplain above the 2810 Road where it crosses Yellowjacket Creek (USFS 1996b).

Bank Stability

Increased sediment deposits in streambeds are contributing to channel widening in many areas (USFS 1996a). It is likely that upslope vegetation removal has increased peak flows that accelerate channel widening and bank erosion. Also, alteration and removal of riparian vegetation has contributed to bank instabilities. Riparian vegetation is the primary factor in streambank stability, providing root holding strength and energy dissipation during debris torrents, road-fill slope failure, or dam-break flood events (USFS 1996a).

The following items summarize bank stability observations within the subbasin.

- In the lower Cispus River, between Quartz and Iron Creek. Cumulative impacts are causing stream widening and bank instability in 20 to 40 percent of the river. From 1959-1994, the Cispus River width was increasing by 30%-70% every 20 years (USFS 1996a).
- There is bank instability and channel widening in lower and upper Quartz Creek. Instability in lower reaches is due to previous timber harvests and road failures. Instability in upper reaches is due mostly to tree blowdown and ash deposits from the 1980 Mt. St. Helens eruption (USFS 1996a).
- In the mainstem Cispus River above Iron Creek, there has been significant channel widening, indicating cumulative sediment loading from upstream subbasins where there has been significant road- and harvest-related, mass wasting events (USFS 1996a and 1996b). The TAG indicates that this condition should improve with new land-management practices on Forest Service lands.
- There are bank stability problems in all stream reaches in lower and middle Iron Creek. Bank stability is a major concern in the Big Creek watershed (upper Iron Creek) where mass wasting was noted in almost all reaches (USFS 1996a).
- 1918 Creek, in the Greenhorn Creek watershed, has bank stability problems, probably due to severe mass wasting in the form of debris flows and from natural erosion processes (USFS 1996b).
- Throughout Yellowjacket Creek, there are areas of poor bank stability and associated channel widening (USFS 1995).
- The North Fork Cispus River confluence experienced channel widening due to aggradation between 1959 and 1979. The likely triggering mechanism was a series of floods in the 1970s. Width at the mouth was 30 feet and 520 feet in 1959 and 1979, respectively (1633% increase). Since 1979, it has started to cut down through the deposits and the channel has narrowed to 240 feet. Tributaries to the North Fork have also experienced channel widening, most of which is attributed to roadfill failures along forest roads 78 and 22 (USFS 1995).

- Mass wasting in East Canyon Creek has caused channel widening and bank instability (Meyers et. al. 2000; USFS 1997a).

Large Woody Debris

Large woody debris (LWD) is lacking in all anadromous streams in this subbasin due to channel cleaning, and timber harvest. TAG members rated instream LWD in Crystal and Orr creeks as “fair” and rated all other streams “poor”. The recruitment potential for LWD in most streams has also been reduced by timber harvest (TAG).

Woody debris is passed over Cowlitz Falls Dam. LWD recovered from Riffe Lake will be recycled upstream by the City of Tacoma to be placed in streams by the USFS (TAG). Some LWD placement projects have already been implemented in Iron and Yellowjacket creeks. The 1996 flooding increased LWD in Iron and Yellowjacket Creeks, but most of it is on the creek margins and is not yet in the creeks (TAG).

Lower Iron Creek has little LWD (USFS 1996a). There is a low recruitment potential for LWD in lower and middle reaches because few areas have late-structural-stage riparian zones. Upper Iron Creek has fair to good LWD (USFS 1996a). While, LWD has increased in Iron Creek due to recent flooding, heavy harvesting by USFS has reduced LWD recruitment potential (TAG).

LWD levels have increased in the mainstem Cispus between Iron Creek and the North Fork Cispus. Recruitment potential is fair to good, with riparian areas in mid- to late-seral stages (TAG). In the North Fork Cispus River, instream LWD is generally poor. Most LWD in the anadromous zone is in debris jams that span the river (USFS 1995). There is, however, good LWD recruitment potential. The USFS has plans for LWD placement in the North Fork Cispus (TAG).

Pool Frequency

Published pool-frequency data in this subbasin is lacking. The TAG rated pool frequency in most streams as "fair", with Crystal and Yellowjacket creeks receiving "poor" ratings. Channel widening and aggradation, combined with low LWD levels have generally reduced the number of pools and pool quality in the Cispus subbasin (USFS 1995).

Barrish and Sorenson (1992) report that the Cispus mainstem (near Woods Creek) has the following channel characteristics: 6% pool, 9% run, 38% glide, and 47% riffle. There is significant channel widening in this area, indicating cumulative sediment loading from upstream (USFS 1996b). This area is important for coho, steelhead, and chinook spawning (TAG). TAG members stated that new land-use and forest practices would eventually decrease sediment loads and increase LWD to this area, so that pool habitat quality and quantity will increase. In the Cispus River, upstream of the North Fork confluence, the average pool depth is greater than 3 feet (USFS 1995).

In the North Fork Cispus, pool frequency is rated "fair", and the TAG states that the existing pools are of good quality. Crystal Creek pools are shallow and offer little holding, rearing or hiding cover. This condition is probably also related to land-use activities (USFS 1996a).

Side Channel Availability

Information on off-channel habitat in this subbasin is generally lacking. There are 13.9 miles of stream-adjacent roads along anadromous streams in this subbasin that likely limit side-channel formation (Lewis County GIS, 2000). Wetlands and off-channel areas have also likely been altered to maintain the Cispus and larger streams in preferred channels. Roads such as 23 and 28 isolate the river from old flood channels (USFS 1996b).

The mainstem Cispus, from Iron Creek to the North Fork, has significant channel widening, indicative of cumulative sediment loading (USFS 1996b). There is potential for side-channel formation here, but the river continues to "move around a lot" creating unstable habitat conditions (TAG). From the North Fork to the end of the anadromous zone on the mainstem Cispus, there are numerous side channels, alcoves, and small tributaries for coho rearing (USFS 1995). There is extensive braiding from RM 29 to RM 35 on the Cispus where important side channel habitat may occur (TAG). The North Fork Cispus generally lacks side channels, tributaries, and alcoves for coho rearing (USFS 1995).

Substrate Fines

The US Forest Service (1995) states that streams in the Cispus subbasin receive sediment inputs above naturally-occurring levels. This is primarily associated with mass wasting from roads and stream crossings, erosion from road surfaces and ditches, and concentrated runoff over land and into streams (USFS 1995). There is also minor contribution from harvest-related mass wasting. Road construction in headwater subbasins is a particular concern due to the occurrence of high stream densities and their ability to deliver an increased amount of sediment to streams and add to peakflow (USFS 1996b).

Road densities within the Cispus subbasin are approximately 1.9 miles of road per square mile. Road densities of less than 2 miles of road per square mile fall in the “good” category using the Conservation Commission’s Habitat Rating Standards (see Appendix B). However, there are areas within the subbasin where roads are contributing unacceptable levels of fine sediments to stream systems. Fine sediment accumulations are a major concern in Greenhorn, Yellowjacket, and McCoy creeks, and in the Cispus River above Quartz Creek. Fine sediments inputs have created embedded substrates in spawning grounds in the North Fork Cispus and in mainstem Cispus above the North Fork confluence (USFS 1995).

The eruption of Mt. St. Helens in 1980 blew down trees in the upper Quartz Creek area and deposited large volumes of ash in the watershed. Sediments are still being delivered to Quartz Creek by rapid, shallow landslides. This condition is expected to continue until herbaceous vegetation reestablishes itself on steep hillsides within the blast zone (USFS

1996a). Rapid, shallow landslides have also been experienced in the lower reaches of Quartz Creek and are attributed to the construction and subsequent failures from the 26 Road, which runs along the length of the creek (USFS 1996a).

"Fair" fine sediment ratings were given to the North Fork Cispus and Crystal, Iron, and Orr creeks. Woods and Ames creeks are rated "good", where management-related sediment delivery has not caused a significant increase over background-delivery levels (USFS 1996a).

Riparian Conditions

Channel widening has been observed in areas where riparian vegetation has been removed. This was more noticeable following debris torrents, road-fill slope failure, or dam-break flood events. Timber harvest has had a profound effect on riparian structure in the Cispus River below Iron Creek (USFS 1996a).

In the mainstem Cispus River between Quartz and Greenhorn creeks, there are continuous, late-seral stage riparian reserves. On the Cispus between Greenhorn and the North Fork Cispus, the riparian forest condition is unknown, with the exception of early seral or non-forested areas along privately owned lands (USFS 1996b). On the Cispus above the North Fork riparian zones are in the mid-seral stage, unfragmented, and continuous (USFS 1995).

The North Fork Cispus River has generally "good" riparian conditions. It has mid- and late-seral forests that are becoming fragmented (USFS 1995), but overall it still has good LWD recruitment potential (TAG). The TAG characterized the North Fork as having one of nicest riparian zones in this ranger district, as well as having all around good habitat conditions. There are old-growth stands throughout the North Fork, with the exception of a portion of the upper watershed, where silver firs were logged after being killed by Mt. St. Helens ash (TAG).

Streams with "fair" riparian ratings include Woods, Ames, Greenhorn, Yellowjacket, and Orr creeks. Lower Woods and Greenhorn creeks have early-seral stage riparian zones, and Yellowjacket Creek riparian conditions are mid-seral stage (USFS 1996a and 1996b; USFS 1995).

Streams with a "poor" rating for riparian conditions included Quartz, Crystal, Iron, Camp, McCoy, and East Canyon Creek. Lower Quartz Creek has the largest, continuous, riparian corridor of late-seral trees in the lower Cispus subbasin, but the upper watershed was in the blowdown area of the 1980 Mt. St. Helens eruption and vegetation is generally in early-seral stage. Crystal Creek has small tree-structure in the upper and lower areas of the watershed (USFS 1996a). Iron and McCoy creeks are lacking late-seral structure and have discontinuous riparian buffers (USFS 1996b; USFS 1995).

Map 11b shows generalized riparian conditions for the Cispus Subbasin, and Table 43 summarizes the data (from Lunetta et. al. 1997; Lewis County GIS 2000). The Cispus

Subbasin has the least percentage of clearly "poor" riparian conditions of any subbasin within WRIA 26. However, it also has the greatest percentage of unknown (early seral stage) riparian conditions. Early seral stage riparian cover ranges from 10% to 70% coniferous canopy cover.

Table 43: Riparian Conditions within the Cispus Subbasin

Basin Name	Riparian Condition	Length (miles)	Percentage
CISPUS	Good	149.69	19.6
	Unknown	557.21	72.8
	Poor	58.17	7.6
Total		*765.07*	*100.0*

Lunetta et. al. 1997; Lewis County GIS 2000.

Water Quality

Water quality in the subbasin varies from marginal to good, based on the assessment of temperature, chemical quality, and turbidity. Riparian vegetation removal as a result of timber harvest, road construction, and volcanic eruption has altered water quality in the subbasin (USFS 1996a; USFS 1995).

Streams with poor ratings due to temperatures above 16°C include the Cispus River above Quartz Creek, Woods Creek, and East Canyon Creek. Temperatures in the upper Cispus watershed indicate that all streams are within the historic, natural range of variability for the Cowlitz basin. The natural range is estimated to be between 11 and 19°C (USDA Forest Service 1993 as cited by USFS 1995). Streams with fair temperature ratings (between 14 and 16°C.) are Quartz Creek and the North Fork Cispus River. "Good" ratings (below 14°C.) were given to Iron and Orr creeks. Orr Creek is in the anadromous zone, but habitat for anadromous use is limited because a constant supply of water from springs is cold enough to prolong egg incubation rates (USFS 1995).

Turbidity has shown a downward trend in Quartz Creek following the 1980 eruption of Mt. St. Helens (354 NTU in 1981 and 64 NTU in 1983). Turbidity in the lower Cispus during the spring and summer is dependent on the amount of glacial flour in the river; however, in the fall and winter it is generally clear (USFS 1996a). During the large flood in December 1995, turbidity was measured at 240 NTU, indicating fines moving through system due to streambank erosion, road failures, and road-surface erosion (USFS 1996a).

Water Quantity

The USFS uses two methods for predicting peakflow sensitivity. One method is Water Available for Runoff (WAR). It is detailed in the Washington State Watershed Analysis Handbook. This method calculates predicted increases in streamflow, with changes in vegetative cover based on rainfall, tree size, temperature, antecedent snow accumulation, and elevation. Aggregate Recovery Percentage (ARP) is the other method, which is detailed in the Gifford Pinchot Cumulative Assessment Process Final Report. It calculates a predicted hydrologic recovery, stand maturity, species, and site class, assuming that an 8-inch diameter stand is 100% hydrologically recovered. This model assumes 100%

hydrologic recovery for non-forest areas. Neither model accounts for soil compaction, or for interception of subsurface flow and increased drainage density caused by road construction (USFS 1996a). Table 44 summarizes WAR and ARP values for the Cispus subbasin. Acceptable values are less than 10% WAR or greater than 70% ARP (USFS 1996a and 1996b).

Table 44 Water quantity values for the Cispus subbasin.

Stream	% WAR	% ARP	Peakflow Rating
Copper Canyon Creek	24	63	**High**
Lower Quartz Creek	16	68	**High**
Upper Quartz Creek	9	45	**High**
Crystal Creek	15	Not calculated	**High**
Mainstem Cispus (Quartz to Iron Creek)	40	Not calculated	**High**
Woods Creek	16	74	**High**
Lower Iron Creek	5	83	Low
Upper Iron Creek	7	69	Moderate
Big Creek (upper Iron Creek)	10	59	**High**
Wakepish Creek (upper Iron Creek)	10	61	**High**
Mainstem Cispus (Iron to Greenhorn Creek)	1.4	89	Low
Nash Creek (tributary to Cispus)	4.5	67	**High**
Lower Greenhorn Creek	4.1	87	Low
Upper Greenhorn Creek	8.9	75	**High**
Mainstem Cispus (Greenhorn to N. Fork)	5.5	95	Moderate
Dry Creek (tributary to Cispus)	11	83	**High**
Camp Creek	13	68	**High**
Lower Yellowjacket Cr.	11	95	**High**
Lambert Creek (lower Yellowjacket)	9.5	85	**High**
Middle Yellowjacket Cr.	3.5	85	Low
Upper Yellowjacket Cr.	4.9	85	Moderate
Pinto Creek. (upper Yellowjacket)	6.7	90	Moderate
Lower McCoy Creek	3.8	96	Low
Upper McCoy Creek	4.3	87	Low

Notes: High = ARP less than 70% and/or WAR greater than 9%.
Moderate = WAR 5%-9%.
Low = WAR less than 5%.
Adapted from USFS 1996a and 1996b; USFS 1995.

Watersheds with "high" ratings have the potential for increased peak flows >10% (USFS 1996b), which can lead to channel alterations and habitat degradation (Chamberlin et. al. 1991). "Moderate" ratings still indicate that increased peak flows have the potential to degrade habitat, but to a lesser degree (USFS 1996a).

Lower elevation subbasins directly adjacent to the Cispus River generally show a moderate to high concern for increased peak flows (USFS 1996b). Peakflow increases in the upper Cispus watershed were not a concern, indicating that management practices have probably not affected peakflow in the upper basin. The low WAR results in the upper subbasin are due in part to moderate harvest levels and also reflect the relatively high elevations above the rain-on-snow zone where the difference in peakflow between fully-mature and fully-harvested conditions result in a small WAR. Nonetheless, calculations show a definite increase in peakflow for three small tributaries outside the anadromous zone in the upper subbasin. Redd scouring is a concern in the Cispus above the North Fork. Data is not available to determine whether spawning-gravel scour is being caused by sediment supply or flooding (USFS 1995).

TAG members mentioned that while the Cowlitz River did not experience extensive flooding during the 1996 flood events, the Cispus River watershed had very high flows.

Biological Processes
In 1999, 35,000 adult coho and 300 adult steelhead were planted near Packwood, in the Yellowjacket Creek area, and in Lake Scanewa. TAG members state that "they go everywhere" to spawn, and rated nutrient placement above the Cowlitz Falls Dam "good" in 1999. TAG members reported that they received many complaints from residents about dead fish.

However, even this level of planting is likely well below historic escapement. Adult salmon and steelhead escapements above the dams were reported at 51,200 in the early 1950s. The EDT analysis (Mobrand Biometrics 1999) estimated that fall chinook and steelhead escapements alone were 31,840 in 1820 (coho and steelhead escapement estimates were not published).

Upper Cowlitz River Subbasin

The Upper Cowlitz Subbasin extends from the Cowlitz Falls Dam (RM 85.5) to the headwaters of the Ohanapecosh, Clear Fork, and Muddy Fork rivers (see Map 4).

Access
The lower dams on the Cowlitz River form a complete barrier to volitional upstream passage of salmonids. Certain species of anadromous fish are trapped below Mayfield Dam and hauled about Cowlitz Falls Dam as part of a reintroduction effort. Downstream passage is provided by a bypass trap at the Cowlitz Falls Dam with hauling to below the Barrier Dam, and passage also occurs through spill and through turbines (Mobrand Biometrics 1999). The efficiency of the smolt trap varies considerably with flow, and fish that are spilled or move through the turbines are lost into Riffe Lake.

Many of the tributaries to the upper Cowlitz River flow through deep, narrow canyons with steep gradients (WDF 1951). Natural barriers to anadromous fish passage, falls, and steep gradients often occur within a mile or two of the confluence with the Cowlitz River (see Map 3b). Of the major tributaries that flow into the upper Cowlitz basin, only the

Cispus River with 33.5 miles of habitat has significant amounts of anadromous habitat available (Hunter and Gerke 1992).

Low-flow and subsurface-flow passage problems occur in many of the upper Cowlitz River tributaries. Some of the problems are associated with channel aggradation due to excessive sediment deposition in lower gradient reaches of the tributaries. Low-flow and subsurface-flow passage problems were noted by the USFS (1997a and 1997b) on:

- Kiona Creek (near Highway 12)
- Peters Creek
- Oliver Creek
- Davis Creek
- Hopkins Creek (Dry from Highway 12 to the mouth)(TAG)
- Kilborn Creek
- Garret Creek
- Burton Creek
- Willame Creek (TAG)
- Purcell Creek (TAG)

A number of artificial barriers were also noted including (see Map 3b):

- A culvert on Siler Creek at FS Road 2304.
- Two culverts on Willame Creek, at FS roads 47 and 4725, were considered passage barriers by the USFS (1997a and 1997b).
- A culvert on Lambert Creek, an important cutthroat stream, may be a passage barrier.
- TAG members also identified a passage barrier on Siler Creek at the Mt. Adams logging mill, where returning adults can't get through ponds that were created on the property.
- An old water diversion structure at the mouth of the canyon on Johnson Creek could attract fish away from the main stream channel and inhibit passage into upstream habitat.
- Channelization of the lower ¼ mile of Smith Creek presents passage difficulties for anadromous fish (Birtchet 1963 as quoted in USFS 1997b).
- Aggradation of the Silver Creek streambed at a falls, that used to be a natural barrier near RM 4.0, has opened new habitat into two miles of Silver Creek and 5.3 miles of Lynx Creek for at least some anadromous salmonids (USFS 1997a).

Floodplain Connectivity

Along the mainstem upper Cowlitz many abandoned river channels are filled in and presently function as farmland or pasture. It is likely that these channels were diked and filled sometime in the late 1800s and early 1900's. The Cowlitz Falls Dam reservoir (Lake Scanewa) inundated approximately 11 miles of multiple, braided channels that once crossed what was an alluviated valley floor with habitat for all life history stages of salmonids. Examination of aerial photos shows evidence of significant downcutting in the lower reaches of the upper Cowlitz after the 1996 flood events (USFS 1997b).

The lower portions of almost every tributary where they enter the Cowlitz River valley has also been affected by agriculture, and residential and industrial development. The streams have been channelized, dredged and diked, and wetlands and associated floodplain habitat has been filled and disconnected from the streams (USFS 1997a and 1997b; Gaia Northwest, Inc.; Harza 1999c). TAG members noted some creeks where floodplain impacts have been extensive and are on-going including:

- Peters Creek where the mouth is continually dredged;
- Miller Creek where a section of the creek is contained within a concrete bed just below Highway 12;
- Silver Creek where the entire lower end has been reshaped, channelized, and straightened;
- Davis Creek where a dike was constructed to protect a house and now the creek has avulsed. A habitat restoration project is supposedly underway;
- Johnson Creek from the highway down to the mouth;
- Hall Creek where a house was recently built within the floodplain;
- Skate Creek where FS Road 52 follows the valley bottom for over 6 miles;
- Butter Creek where diking and dredging has occurred to protect the High Valley subdivision; and
- Coal Creek where heavy development has occurred on the floodplains.

Bank Stability

The upper Cowlitz River mainstem (above Cowlitz Falls Dam) has generally poor channel stability as the river meanders within floodplain deposits. An EDT analysis conducted by Mobrand Biometrics (1999) rates the changes in channel stability from historic conditions as high for this reach of the Cowlitz mainstem. Excessive sediment delivery from a number of tributaries has aggraded the channel and increased the width-to-depth ratios, placing pressure on the stream banks (USFS 1997a: Meyer et. al. 2000: letter). Farming and grazing along the banks has also resulted in severe erosion and a reduction in riparian habitat (Harza 1997b). The river banks along some of the pasture lands just upstream of Kilborn Creek (RM 115) are continually undercut and in some locations over 20 feet in height (USFS 1997b). Upstream from this undercutting TAG members noted that streambank stability improves. The EDT analysis (Mobrand Biometrics 1999) also shows steady improvement in channel stability moving upstream from RM 118.

On many of the Cowlitz tributaries data is lacking on bank stability. However, on tributaries where surveys have occurred it appears that there has been a general widening of channels with high width-to-depth ratios (USFS 1997a and 1997b; Murray Pacific Corporation 1995).

Problem areas noted included:

- Scattered areas of channel instability and high width-to-depth ratios occur in Davis Creek (primarily from RM 2.5-3.5). The streambed is deeply entrenched in some areas of the lower reaches with very high banks (USFS 1997b);
- Bank scour was identified as a problem in the middle reaches of the lower Silver Creek (USFS 1997a) and in Garrett Creek where it is contributing to an increase in sedimentation in the channel, so that pools are fairly shallow and some filling with coarse material is occurring (USFS 1997b);
- In Skate Creek, USFS (1997b) recommended width-to-depth ratios were exceeded for all measured reaches of the creek;
- In Kiona, Peters, and Oliver Creeks examination of aerial photos found visible widening of channels in portions of the creek following debris flows and dam-break floods in 1939, 1966, 1974, 1988, and 1990 (Murray Pacific 1995).

Large Woody Debris

Historically, abundant LWD and numerous log jams were present in the upper Cowlitz River channel; now there is very little (Mobrand 1999; USFS 1997a). Above RM 115 in the upper Cowlitz River the USFS (1997b) rates LWD abundance as fair to good with scattered wood along the transverse bars and in small jams. However, overall LWD densities are not at full potential because recruitment is limited. The watershed has been affected by prior management activities that removed LWD from the floodplains and/or removed potential LWD from the riparian zones (Lanigan et al. 1998). Post-flood surveys found that there was an influx of LWD during the 1995-1996 floods to most areas; however, most LWD on private lands was subsequently removed (Lanigan et. al. 1998).

Almost all the tributaries to the upper Cowlitz subbasin also have “poor” LWD abundance. Murray Pacific (1995) attributes the overall poor LWD abundance to past debris flows, riparian clearing, active removal, loss of recruitment, natural decay, and attrition. Some systems that are exceptions with generally good LWD abundance include the Ohanapecosh River, Clear Fork River, and Purcell Creek watersheds where 84%, 58%, and 59%, respectively, of the surveyed reaches of the river had good levels of LWD (USFS 1998). The USFS (1998) believes that LWD is abundant and not a limiting factor for the Ohanapecosh, Clear Fork, and Muddy Fork systems (Meyer et. al. 2000: letter). However, Harza (1997b) states that LWD was virtually absent in the lower reaches of the Ohanapecosh River.

LWD recruitment potential is generally low for most areas within the upper Cowlitz River subbasin. Kiona Creek has mainly young deciduous trees within the riparian zones, creating a low LWD recruitment potential. Future LWD requirement would also likely be low on Silver, Davis, Garrett, Burton, Willame, Smith, Hall, Skate, and Butter creeks (especially along the lower reaches) (Meyer et. al. 2000: Lanigan et. al. 1998: USFS 1997a; USFS 1997b).

Pool Frequency

The upper Cowlitz River channel is receiving high sediment loads that are slowly but continually routed through the system (USFS 1998). Sediment pulses often partially or completely fill existing pools along the channel, and habitat in this reach is dominated by riffle habitat with a cobble, gravel substrate (USFS 1997b). Pools are infrequent and of limited depth (Harza 1997b). While this reach of the Cowlitz would be naturally dominated by riffle habitat, width-to-depth ratios along the upper Cowlitz channel are considered to be greater than found under normal conditions, and where pool habitat exists it generally lacks suitable cover (USFS 1997a and 1997b).

Where data was available, pool habitat is generally poor for at least the lower reaches of most of the tributaries, including Siler, Kiona, Peters, Oliver, Miller, Silver, Davis, Kilborn, Garrett, Willame, Smith, Johnson, Skate, Butter, and the lower Muddy Fork (USFS 1997a and 1997b). Excessive sediment deposits and the lack of LWD were often cited as the cause for a lack of pools and high depth-to-width ratios in these tributary watersheds (USFS 1997a; USFS 1997b; Murray Pacific 1995; Lanigan et. al. 1998: Meyers et. al. 2000: letter). Some notable exceptions with good pool habitat included lower Lake and Burton creeks, and the Ohanapecosh and Clear Fork Cowlitz rivers (USFS 1997a and 1997b).

Side Channel Availability

The Cowlitz Falls Dam reservoir (Lake Scanewa) inundated 11 miles of multiple, braided channels that crossed what was an alluviated valley floor (Mobrand 1999; Gaia Northwest, Inc. 1993). Even the lower mile of the Cispus River was flooded as the reservoir filled. Examination of aerial photos shows evidence of significant downcutting in the lower reaches of the upper Cowlitz River (between approximately RM 100 and RM 115) after the 1996 flood events which may have further reduced connection to side channel habitat (USFS 1997b). From RM 115 to the confluence with the Clear Fork the USFS (1997b) describes the Cowlitz channel as having numerous side channels that are filled with LWD and have substrates ranging from silt/sand to cobble/sand-gravel.

Little data exists on the availability of side channels in the tributaries to the Cowlitz. Yet, only the lower reaches of most tributaries have shallow gradients where side channel habitat is likely to form, and these areas have generally been channelized, dredged, and diked. Streams with degraded side channel habitat include Butter, Skate, Miller, Purcell, Coal, Lake, Hall, Johnson, Smith, Burton, Kilborn, Hopkins, Davis, Surrey, Silver, Oliver, Peters, and Kiona creeks (Murray Pacific 1995; USFS 1997a and 1997b; Lanigan et. al. 1998: Meyers et. al. 2000: letter).

Substrate Fines

Historically, the dominant sediment sources in the upper Cowlitz were deep-seated rotational mass movements, which were located at the base of mountain structures, or avalanche and debris chutes from steep ridges. Small inner gorge failures and channel erosion were also sources of sediment, but to a much lesser extent than the chutes in the upper watershed (USFS 1997b). Potentially severe erosion would occur on over 83% of the Cowlitz subbasin land if vegetative cover were removed (USSCS 1974)

Recent floodplain development, riparian impacts, channelization of several tributaries, and a lack of LWD has resulted in increased sediment delivery to the mainstem Cowlitz River channel above Cowlitz Falls Dam (USFS 1997b: Meyer et. al. 2000: letter; Mobrand Biometrics 1999). The amount of increase in sediment inputs is unknown. The mainstem of the upper Cowlitz River continues to route sediments through the watershed; however, enough sediment deposition has occurred to cause problems with stream channel migration, high width-to-depth ratios, and loss of pool habitat (USFS 1997b). Lanigan et. al. (1998) state that post-flood assessments of stream conditions in the Middle Cowlitz River (RM 88.5-RM 115) found the area “at risk” because of increased fines in gravel.

In the LFA habitat rating standards, road densities are used as a surrogate to measure excessive fine sediment inputs to stream systems (see Appendix B). With 1066.1 miles of roads within an area of 567.5 square miles, road densities within the Upper Cowlitz Subbasin are approximately 1.87 miles of road/square mile, which falls in the good category. There are 23.9 miles of stream adjacent roads (within 200 feet of anadromous streams) within the subbasin that also contribute fine sediments to stream channels. Skate Creek has roads that closely follow the stream for over half of the anadromous zone (see Map 10b).

Additionally, sedimentation of the many key tributary channels to the upper Cowlitz including Kiona, Oliver, Peters, Miller, Hampton, Silver, Siler, Kilborn, Davis, Smith, Johnson, lower Lake, lower Coal, lower Butter, Skate, and both the North Fork and main stem Willame Creek limits both the quantity and quality of fish production within the Upper Cowlitz River Subbasin (USFS 1997a; USFS 1997b; Meyer et. al. 2000; letter). Ditching, diking, dredging, and channelization has increased water velocities in many of these channels, and thus increased the cutting action and erosion potential in the channel leading to additional problems downstream in depositional areas (USFS 1997a) Portions of Kiona, Oliver, Kilborn, Garret, Burton, Peters, Miller and Hampton Creeks flow subsurface for portions of the year due to an over-load of sediment in the stream channel, and anadromous habitat is lost (USFS 1997a). In other areas, increased water velocities have reduced available spawning habitat by scouring spawning gravels out of once productive spawning habitat (Meyers et. al. 2000: letter).

Other sediment conditions that were noted by TAG members included:

- The Forest Service has recently decommissioned 3 to 4 miles of roads and upgraded culverts in the Davis Creek watershed;
- Peters Creek has 300 yards, at most, with spawning gravel available;
- Despite the extensive logging that has occurred within the Kiona Creek watershed there are still some excellent spawning grounds remaining.

Riparian Conditions:

Land use activities (farming, grazing, timber harvesting, and industrial and residential development) have removed most of the mature riparian vegetation on private lands along the upper Cowlitz River and along at least the lower gradient portions of most tributaries feeding the upper Cowlitz (Harza 1997b; USFS 1997a; USFS 1997b; Meyer et. al. 2000: letter). A study of riparian cover within a fixed width 1000-foot buffer along the Cowlitz mainstem from Mayfield Dam to the Clear Fork and along the lower Cispus River found that about 42% of the area can be characterized as mid-successional conifer, deciduous, and mixed forest (Harza 1999a) (see Table 45). In the entire upper Cowlitz River Forest Service analysis area, all WAU's except Lake Creek and Coal Creek have less than 40% of the riparian areas in the large-tree structural class (USFS 1997b). Over the entire upper Cowlitz watershed, grass/pole, small tree, and non-forested structural stages of vegetation cover approximately 72% of the land area, while only 28% has large tree cover (USFS1997b). Based on stream survey data (Lanigan et. al.1998) areas with fully functioning riparian zones do exist; however, they are generally limited and disconnected for most of the Cowlitz River watershed above the Cowlitz Falls Dam.

Table 45: Total acreage and percent of each cover type within 1,000-foot buffer along the upper Cowlitz River (Mayfield Dam to Clear Fork)

Cover Type	% Mature	% Mid-successional	% Old-Growth	% Pole	% Seed/Sap	Total Acres
Agriculture	0	0	0	0	0	28.2
Conifer Forest	3.2	53.7	0	2.7	40.4	3,461.0
Commercial*	0	0	0	0	0	76.5
Deciduous Forest	19.5	70.3	2.3	7.5	0.4	3,012.8
Project Facilities*	0	0	0	0	0	44.5
Mixed Forest	8.9	91	0	0.1	0	1,101.9
Grass/Meadow*	0	0	0	0	0	2,151.5
Palustrine Aquatic Bed*	0	0	0	0	0	11.2
Palustrine Emergent	0	0	0	0	0	56.5
Palustrine Forest		80	0	20	0	41.7
Palustrine Open Water*	0	0	0	0	0	33.1
Palustrine Scrub-Shrub*	0	0	0	0	0	69.4
Recreation*	0	0	0	0	0	99.4
Riverine Emergent	0	0	0	0	0	0
Residential*	0	0	0	0	0	129.7
Rock Outcrop*	0	0	0	0	0	1.1
Rock Pit*	0	0	0	0	0	34.1
Riverine Scrub-Shrub	0	0	0	0	0	0
Riverine Unconsolidated Shore*	0	0	0	0	0	1,240.7
Shrubland*	0	0	0	0	0	175.1
Total Acreage	796.2	5,012.3	68.8	330.2	1,409.9	11,768.6

* Structure class is assigned only to forested cover types
Adapted from Harza 1999 Vol. 2 Technical Study Reports.

Significant riparian problems exist on many of the tributaries to the upper Cowlitz. Of the 697 acres of designated riparian vegetation along Kiona Creek 59% was classified as grass/pole (<9" dbh), and the remaining 41% was small tree (9" to 20.9" dbh)(USFS 1997a). For the entire 6th field watershed (including Peters and Oliver Creeks) only 4% of the riparian reserves have a "large tree" (>20.9" dbh) classification (USFS 1997a). Reflecting the poor riparian conditions in the Kiona creek watershed, water temperatures have exceeded state standards and DO was measured at below state standards in Kiona Creek and it's tributaries, Oliver and Peters creeks (USFS 1997a).

Map 11b shows generalized riparian conditions for the Upper Cowlitz Subbasin (from Lunetta et. al. 1997; Lewis County GIS 2000). Riparian conditions along the mainstem Cowlitz are clearly poor for almost the entire length of anadromous habitat. The lower reaches of many of the upper Cowlitz River tributaries also have poor riparian conditions. Table 46 summarizes the riparian conditions data for the Upper Cowlitz Subbasin. The subbasin has the greatest percentage (27.7%) of "good" riparian habitat in WRIA 26.

Table 46: Riparian Conditions in the Upper Cowlitz Subbasin

Basin Name	Riparian Conditions	Length (miles)	Percentage
UPPER COWLITZ	Good	250.73	27.7
	Unknown	447.34	49.4
	Poor	207.91	22.9
Total		*905.99*	*100.0*

Lunetta et. al. 1997; Lewis County GIS 2000.

Water Quality

Water flowing from the major tributaries that feed the upper Cowlitz (Clear and Muddy Forks, and Ohanapecosh River) is generally cool, well oxygenated, and of similar quality to historic conditions (USFS 1998). Two streams on the upper Cowlitz were listed on the 1996 and 1998 303d list for temperature exceedances above state standards, Silver Creek and Willame Creek. The USFS measured 72 excursions beyond Washington State criteria for water temperatures in Silver Creek in 1992-1993; 21 excursions in 1996; and 7 excursions in 1997. Water temperatures in Willame Creek exceeded state criteria 6 times in 1996.

While Kiona Creek was not listed on the 303d list for water temperature, Beak Consultants (1995) measured water temperatures that exceeded state standards (16 degrees C) in 1992, 1993, and 1994, and exceeded 20 degrees C in 1994 (Murray Pacific 1995). Two tributaries to Kiona Creek, Peters and Oliver Creeks, also had similar water temperatures, as well as low dissolved oxygen (DO) levels when measured in 1992, 1993, and 1994 (Murray Pacific 1995). The USFS Middle Cowlitz Watershed Analysis (1997a) states that the excessive water temperatures likely relates to the poor riparian conditions within the Kiona Creek watershed.

Other areas where water quality exceeds state standards include:

- Lake Creek where water temperatures reach 18 degrees C near where surface water from Packwood Lake enters the creek (USFS 1997b). Elevated water temperatures in this system are likely due to natural causes (TAG);

- Miller Creek where water quality may be a problem from sewage and garbage disposal into the creek at Randle (USFS 1997a);
- Glacial melt in the headwaters of the Cowlitz River elevates turbidity over 5 NTUs (up to 17 NTUs) in the river above Cowlitz Falls Dam during the summer and early fall (Harza 1999c).

Water Quantity

Most of the information available on changes in peak flows for watersheds within the upper Cowlitz basin comes from Upper and Middle Cowlitz Watershed Analysis developed by the USFS (1997a and 1997b). Two methods were used to calculate changes in peakflow over natural conditions; the WAR and ARP. The Water Available for Run-off (WAR) model estimates increases in stream flow due to changes in vegetative cover based on rainfall, tree size, temperature, antecedent snow accumulation, and elevation. WAR values on the National Forest were calculated from current vegetation data and digital elevation models. WAR values of >10% can lead to increased peak flows causing scour and channel degradation (see Table 47).

Table 47 Water Quantity Concerns

Stream	% Area in Rain-on-Snow Zone	Low flow Problems	WAR - % Increase in Peakflow	% ARP	Peakflow Rating
Cowlitz R. (RM 88.5-115	8	No	45.2	70	**High**
Kiona Creek	59	Yes	17.9	60	**High**
Peters/Oliver Cr.	45	Yes			**High**
Miller	53	Yes	21.3	78	**High**
Upper Silver Cr.	63	None Noted	9.1	59	**High**
Lower Silver Cr.	70	None Noted	9.0	71	Moderate
Siler Cr.	23	None Noted	18.1	84	Moderate
Surrey/Hopkins Cr.	37	Yes	22.1	89	Moderate
Cowlitz R. (RM 115-134	19	No	12.6	82	Moderate
Burton Cr.	19	Yes	12.6	82	Moderate
Smith Cr.	7	None Noted	5.8	89	Low
Johnson Cr.	8	None Noted	3.6	91	Low
Lake Cr.	11	None Noted	3.7	95	Low
Coal Cr.	11	None Noted	4.3	91	Low
Hall Cr.	22	None Noted	17.6	68	*High*
Butter Cr.	11	None Noted	7.9	86	Moderate
Skate Cr.	14	None Noted	6.1	84	Moderate
Willame Cr.	28	Yes	7.7	80	*High*
Davis Cr.	17	Yes	11.7	81	**High**
Kilborn Cr.	13	Yes	11.2	79	**High**
L. Muddy Fork	30	No	10.7	99	Low
Purcell Cr.	29	No	11.5	87	Low
L. Ohanapecosh	45	No	11.6	92	Low
L. Clear Fork	10	No	N/A	90	Low

Adapted from USFS 1997a and 1997b.

The ARP method calculates a predicted hydrologic recovery for a basin based on stand year of origin, species composition, and site class. A stand is considered 100% hydrologically recovered once it reaches an average dbh of 8 inches. ARP values of 70% or less would likely mean adverse impacts to water quality and stream channel degradation (see Table 47).

In general, the potential for increased peak flows is highest in the lower subbasins of the upper Cowlitz. Moving upstream, most of the land base is located in the National Forest, Wilderness areas, and Rainer National Park where vegetation cover is similar to historic conditions. Only within Hall, Davis, Willame, and Kilborn creeks is the potential for increased peak flows rated as high (see Table 47).

Low-flow and subsurface flow passage problems also occur in many of the upper Cowlitz River tributaries. Some of the problems are associated with channel aggradation due to excessive sediment deposition in lower gradient reaches of the tributaries. Low-flow and subsurface-flow passage problems were noted by the USFS (1997a and 1997b) on:

- Kiona Creek (near Highway 12),
- Peters Creek,
- Oliver Creek,
- Davis Creek,
- Hopkins Creek (Dry from Highway 12 to the mouth)(TAG),
- Kilborn Creek,
- Garret Creek,
- Burton Creek,
- Willame Creek (TAG),
- Purcell Creek (TAG).

Biological Processes

Table 48 from Harza (1999c) provides historical estimates of the spawning escapement in the upper Cowlitz River above Mayfield Dam. Considering that last year approximately 35,000 coho, and 100 steelhead were released above the dam, the number of returning adults to the upper Cowlitz subbasin is obviously well below historic returns. Habitats in the Upper Cowlitz River Subbasin are likely not receiving adequate nutrients from the carcasses of spawned out fish to fully support the aquatic and riparian communities.

Table 48: Historic Spawning Escapement Estimates

Species	Spawning Escapement
Spring Chinook	9,000
Fall Chinook	14,000
Steelhead	24,000
Coho	11,000
Cutthroat	24,861
Total	*82,861*

Adapted from Harza 1999c

ASSESSMENT OF HABITAT LIMITING FACTORS

In order to develop a set of standards to rate salmonid habitat conditions, several tribal, state, and federal documents that use some type of habitat rating system were reviewed (see Habitat Rating Standards in Appendix B). The goal was to identify appropriate rating standards for as many types of limiting factors as possible, with an emphasis on those that could be applied to readily available data. Based on the review, it was decided to rate habitat conditions into three categories: Good, Fair, and Poor. For habitat factors that had wide agreement on how to rate habitat condition, the accepted standard was adopted by the Washington Conservation Commission (WCC). For parameters that had a range of standards, one or more of them were adopted. Where no standard could be found, a default rating standard was developed, with the expectation that it will be modified or replaced as better data become available.

The habitat condition ratings are not intended to be used as thresholds for regulatory purposes, but as a coarse screen to identify the most significant limiting factors in a Water Resource Inventory Area (WRIA). They also will hopefully provide a level of consistency between WRIAs that allows habitat conditions to be compared across the state. However, for many habitat factors, there may not be sufficient data available to use a rating standard or there may be data on habitat parameters where no rating standard is provided. For these factors, the professional judgment of the TAG was used to assign the appropriate ratings.

The Technical Advisory Group (Tag) for WRIA 26 developed Table 49 using the rating standards in Appendix B as a guide to rate habitat conditions within WRIA 26. The information came from both published and unpublished studies, and the personal and professional experiences of TAG members. Within some subbasins, both personal experience and quantitative data was lacking, and these areas are identified with a ND (no data) designation.

The following assessment provides recommendations from the TAG for addressing habitat limiting factors within WRIA 26, as well as, in each subbasin (the Coweeman River, Toutle River, Lower Cowlitz, Tilton/Mayfield, Riffe Lake, Cispus River, and Upper Cowlitz subbasins). The TAG did not prioritize these recommendations. TAG members felt that prioritization would require the further development of a standardized methodology that could be applied within as well as across basins.

Table 49: Habitat Limiting Factors by Subbasin

Stream Name	WRIA Index	Fish Passage	Floodplain Connect	Bank Stability	Large Woody Debris	Pool Ratio and Pools/Mile	Side Channels	Substrate Fines	Riparian Conditions	Water Quality	Water Quantity	Biological Processes
Coweeman Basin												
Coweeman (diked area RM 0 to RM 4)	**260003**	**G** [2]	**P** [2]	**G** [2]	**P** [2]	**G** [2]	**P** [2]	**NA**	**P** [1]	**P** [1]	**F** [2]	**P** [1]
Coweeman (dike end to cable crossing, RM 4 to RM 7.45)	**260003**	**G** [2]	**F** [2]	**F** [2]	**P** [2]	**G** [2]	**F** [2]	**P** [2]	**P** [2]	**ND**	**F** [2]	**P** [1]
Unnamed Creek	**260019**	**P** [2]	**NA**	**G** [2]	**P** [2]	**P** [2]	**NA**	**F** [2]	**P** [2]	**ND**	**ND**	**P** [1]
Coweeman (cable crossing to Mulholland, RM 7.45 to RM 18.4)	**260003**	**G** [2]	**NA**	**G** [2]	**P** [2]	**G** [2]	**NA**	**G** [2]	**P** [2]	**ND**	**F** [2]	**P** [1]
Turner Creek	**260026**	**P** [2]	**NA**	**G** [2]	**P** [2]	**F** [2]	**NA**	**F** [2]	**P** [2]	**ND**	**ND**	**P** [1]
Nye Creek	**260030**	**P** [2]	**NA**	**G** [2]	**P** [2]	**P** [2]	**NA**	**ND**	**P** [2]	**ND**	**ND**	**P** [1]
Goble Creek	**260035**	**G** [2]	**NA**	**G** [2]	**F** [2]	**F** [2]	**NA**	**ND**	**P** [2]	**P** [1]	**ND**	**P** [1]
Mulholland	**260084**	**G** [2]	**ND**	**P** [1]	**P** [2]	**P** [1]	**F** [2]	**F** [1]	**P** [1]	**P** [1]	**ND**	**P** [1]
Baird	**260101**	**F** [2]	**ND**	**P** [1]	**P** [1]	**P** [1]	**ND**	**ND**	**P** [1]	**P** [1]	**ND**	**P** [1]
Owl Creek	**261441**		**G** [2]	**G** [2]	**P** [2]	**P** [2]	**P** [2]	**P** [2]	**P** [2]	**ND**	**ND**	**P** [1]
Unnamed (Pin Creek)	**---**	**P** [2]	**F** [2]	**F** [2]	**P** [2]	**P** [2]	**F** [2]	**P** [2]	**P** [2]	**ND**	**ND**	**P** [1]
Coweeman Mulholland (RM 18.4) to headwaters	**260003**	**G** [1]	**F** [1]	**ND**	**P** [1]	**P** [1]	**ND**	**P** [1]	**P** [1]	**P** [1]	**F** [2]	**P** [1]
Cowlitz Mainstem RM 0 to RM 20 (Toutle River)	**260002**	**G** [2]	**P** [2]	**G** [2]	**NA**	**P** [2]	**P** [2]	**NA**	**P** [2]	**P** [1]	**F** [1]	**P** [1]
Unnamed Creek	**260125**	**P** [2]	**P** [2]	**P** [2]	**P** [2]	**P** [2]	**P** [2]	**P** [2]	**P** [2]	**ND**	**ND**	**P** [1]
Unnamed Creek	**260128**	**P** [2]		**G** [2]	**P** [2]	**NA**	**NA**	**P** [2]	**P** [2]	**ND**	**ND**	**P** [1]
Ostrander Creek	**260132**	**G** [2]	**G** [2]	**G** [2]	**P** [2]	**F** [2]	**G** [2]	**ND**	**P** [2]	**ND**	**P** [1]	**P** [1]
Unnamed Creek (@Headquarters Rd.)	**260184**	**P** [2]	**P** [2]	**G** [2]	**P** [2]	**P** [2]	**P** [2]	**P** [2]	**P** [2]	**ND**	**ND**	**P** [1]
Unnamed Creek	**260186**	**P** [2]	**P** [2]	**G** [2]	**P** [2]	**P** [2]	**P** [2]	**P** [2]	**P** [2]	**ND**	**ND**	**P** [1]
Salmon Creek	**260187**	**G** [2]	**F** [2]	**G** [2]	**P** [2]	**P** [2]	**F** [2]	**P** [2]	**P** [2]	**ND**	**ND**	**P** [1]
Toutle Basin												
Mainstem Toutle	**260227**	**G** [2]	**P** [1]	**F** [1]	**P** [2]	**ND**	**G** [2]	**P** [2]	**P** [2]	**P** [2]	**P** [2]	**P** [1]
Cline Creek	**260230**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**P 1**
Stankey Creek	**260232**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**P** [1]
Outlet Creek	**260239**	**P** [1]	**P** [1]	**G** [2]	**P** [2]	**P** [2]	**P** [1]	**P** [2]	**P** [2]	**P** [1]	**P** [1]	**P** [1]
Silver Lake		**ND**	**ND**	**ND**	**ND**	**NA**	**NA**	**NA**	**ND**	**P** [1]	**ND**	**P** [1]
Hemlock Creek	**260240**	**P** [1]	**P** [1]	**F** [1]	**P** [1]	**P** [1]	**P** [1]	**P** [1]	**P** [1]	**P** [1]	**ND**	**P** [1]
Sucker Creek	**260245**	**P** [1]	**ND**	**F** [1]	**P** [1]	**P** [1]	**P** [1]	**P** [1]	**P** [1]	**P** [1]	**ND**	**P** [1]

Stream Name	WRIA Index	Fish Passage	Floodplain Connect	Bank Stability	Large Woody Debris	Pool Ratio and Pools/Mile	Side Channels	Substrate Fines	Riparian Conditions	Water Quality	Water Quantity	Biological Processes
S. Fork Toutle	260248	G [2]	P [2]	P [2]	P [2]	P [2]	F [2]	P [2]	P [2]	P [1]	P [2]	P [1]
Studebaker Creek	260249	P [2]	G [2]	G [2]	F [2]	F [2]	ND	P [2]	P [2]	ND	ND	P [1]
Johnson Creek	260254	F [2]	P [2]	ND	F [2]	F [2]	ND	P [2]	ND	ND	ND	P [1]
Brownell Creek	260261	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	P [1]
Jordan Creek	260262	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	P [1]
Thirteen Creek	260265	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	P [1]
Eighteen Creek	260268	ND/ P [2]	ND	ND	ND	ND	ND	ND	ND	ND	ND	P [1]
Twenty Creek	260273	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	P [1]
Big Wolf Creek	260274	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	P [1]
Whitten Creek	260285	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	P [1]
Bear Creek	260288	ND	ND	ND	ND	ND	ND	ND	P [1]	ND	ND	P [1]
Herrington Creek	260294	G [2]	ND	ND	P [2]	F [1]	ND	P [2]	P [2]	ND	ND	P [1]
Coldspring Creek	260306	ND	ND	ND	ND	ND	ND	ND	P [1]	ND	ND	P [1]
N. Fork Toutle (mouth to fish barrier)	260314	G [2]	P [2]	G [2]	P [2]	P [2]	G [2]	P [2]	P [2]	P [2]	P [2]	P [1]
Wyant Creek	260315	P [2]	G [2]	ND	P [2]	G [1]	ND	P [2]	P [2]			
N. Fork Toutle (barrier to headwaters)	260314	P [2]	G [2]	P [1]	P [2]	P [2]	G [2]	P [2]	P [2]	P [2]	P [2]	P [1]
Alder Creek	260387	**ND	N/A	ND	F [2]	G [1]	ND	P [2]	P [2]	ND	ND	P [1]
Hoffstadt Creek	260396	**G [2]	N/A	P [1]	F [2]	G [2]	ND	ND	P [2]	ND	ND	P [1]
Bear Creek	260397	**ND	ND	P [1]	P [1]	ND	ND	P [2]	P [1]	ND	ND	P [1]
Deer Creek	260404	**ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	P [1]
Jackson Creek	260410	**ND	ND	P [1]	ND	ND	ND	ND	P [1]	ND	ND	P [1]
Elk Creek	260413	**ND	ND	P [1]	ND	ND	ND	ND	P [1]	P [1]	ND	P [1]
Castle Creek	260415	**ND	ND	P [1]	ND	ND	ND	ND	P [1]	ND	ND	P [1]
Maratta Creek	260417	**ND	ND	P [1]	ND	P [1]	ND	ND	P [1]	ND	ND	P [1]
Coldwater Creek	260418	**ND	ND	P [1]	ND	ND	ND	ND	P [1]	ND	ND	P [1]
												P [1]
Green River (mouth to USFS boundary [below Miners Creek])	260323	P [2]	P [2]	P [1]	P [2]	P [1]	F [1]	P [1]	P [2]	P [2]	P [2]	P [1]
Beaver Creek	260325	ND	ND	ND	ND	ND	ND	ND	ND	P [1]	ND	P [1]
Jim Creek	260329	P [2]	ND	ND	ND	ND	ND	ND	ND	ND	ND	P [1]
Devils Creek	260330	ND	N/A	G [2]	P [2]	P [2]	N/A	F [2]	P [2]	ND	ND	P [1]
Cascade Creek	260348	ND	ND	ND	P [1]	ND	ND	ND	ND	ND	ND	P [1]
Elk Creek	260353	ND	ND	ND	ND	ND	ND	G [2]	P [1]	P [1]	ND	P [1]
Schultz Creek	260359	ND	ND	ND	ND	ND	ND	ND	P [1]	ND	ND	P [1]
Tradedollar Creek	260363	ND	ND	ND	ND	ND	ND	ND	P [1]	ND	ND	P [1]
Miners Creek	260365	ND	ND	ND	ND	ND	ND	ND	P [1]	ND	ND	P [1]

Stream Name	WRIA Index	Fish Passage	Floodplain Connect	Bank Stability	Large Woody Debris	Pool Ratio and Pools/Mile	Side Channels	Substrate Fines	Riparian Conditions	Water Quality	Water Quantity	Biological Processes
Lower Cowlitz Basin												
Cowlitz River (Toutle R. to Barrier Dam)	**260002**	**G**[2]	**G**[2]	**P**[2]	**P**[2]	**P**[1]	**F**[1]	**G**[1]	**P**[2]	**G**[1]	**F**[2]	**P**[1]
Westover Creek	**260123**	**P**[2]	**P**[2]	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**P**[1]
McCorkle Creek	**260163**	**P**[2]	**P**[2]	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**P**[1]
Leckler Creek	**260169**	**P**[1]	**F**[1]	**P**[1]	**P**[1]	**P**[1]	**P**[1]	**P**[1]	**P**[1]	**P**[1]	**P**[1]	**P**[1]
Arkansas Creek	**260189**	**G**[1]	**P**[1]	**P**[1]	**P**[1]	**P**[1]	**P**[1]	**P**[1]	**P**[1]	**P**[1]	**ND**	**P**[1]
Delameter Creek	**260192**	**G**[1]	**P**[1]	**F**[1]	**P**[1]	**P**[1]	**P**[1]	**P**[1]	**P**[1]	**P**[1]	**ND**	**P**[1]
Monahan Creek	**260195**	**P**[1]	**G**[1]	**G**[1]	**P**[1]	**P**[1]	**ND**	**ND**	**P**[1]	**G**[1]	**ND**	**P**[1]
Tucker Creek	**260209**	**P**[2]	**G**[1]	**G**[1]	**P**[1]	**P**[1]	**P**[1]	**P**[1]	**P**[1]	**F**[1]	**ND**	**P**[1]
Baxter Creek`		**ND**	**ND**	**ND**	**ND**	**P**[1]	**ND**	**ND**	**ND**	**ND**	**ND**	**P**[1]
Whittle Creek	**260225**	**G**[1]	**P**[1]	**P**[1]	**P**[1]	**P**[1]	**P**[1]	**P**[1]	**P**[1]	**P**[1]	**P**[1]	**P**[1]
Rock Creek	**260422**	**ND**	**ND**	**ND**	**ND**	**P**[1]	**ND**	**ND**	**ND**	**ND**	**ND**	**P**[1]
Hill Creek	**260423**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**P**[1]
Olequa Creek	**260427**	**G**[2]	**ND**	**G**[2]	**P**[2]	**F**[1]	**ND**	**F**[2]	**P**[2]	**P**[1]	**P**[1]	**P**[1]
Stillwater Creek	**260429**	**G**[2]	**ND**	**G**[2]	**P**[2]	**P**[2]	**ND**	**F**[2]	**P**[2]	**ND**	**ND**	**P**[1]
Brim Creek	**260432**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**P**[1]
N. Fork Brim Cr.	**260434**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**P**[1]
Campbell Creek	**260443**	**ND**	**ND**	**ND**	**ND**	**P**[1]	**ND**	**ND**	**ND**	**ND**	**ND**	**P**[1]
Becker Creek	**260448**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**P**[1]
Snow Creek	**260456**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**P**[1]
Ferrier Creek	**260457**	**P**[2]	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**P**[2]	**ND**	**ND**	**P**[1]
King Creek	**260461**	**ND**	**ND**	**ND**	**ND**	**P**[1]	**ND**	**ND**	**P**[2]	**ND**	**ND**	**P**[1]
North Fork Olequa	**260464**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**P**[1]
Lacamas Creek	**260467**	**G**[2]	**G**[2]	**G**[2]	**P**[2]	**P**[1]	**ND**	**P**[2]	**P**[2]	**ND**	**ND**	**P**[1]
Bear Creek	**260468**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**P**[2]	**ND**	**ND**	**P**[1]
Coon Creek	**260469**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**P**[2]	**ND**	**ND**	**P**[1]
Mill Creek	**260470**	**P**[2]	**ND**	**ND**	**ND**	**P**[1]	**ND**	**ND**	**ND**	**ND**	**ND**	**P**[1]
Foster Creek	**260475**	**P**[2]	**G**[2]	**F**[2]	**ND**	**ND**	**ND**	**P**[2]	**P**[2]	**ND**	**ND**	**P**[1]
Salmon Creek	**260479**	**G**[2]	**P**[2]	**P**[2]	**P**[2]	**P**[1]	**ND**	**P**[2]	**P**[2]	**ND**	**P**[1]	**P**[1]
Little Salmon Creek	**260481**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**P**[1]
Cedar Creek	**260482**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**P**[1]
Skook Creek	**260521**	**P**[2]	**ND**	**ND**	**ND**	**G**[1]	**ND**	**F**[1]	**P**[2]	**ND**	**ND**	**P**[1]
Blue Creek	**260527**	**P**[2]	**ND**	**ND**	**ND**	**F**[1]	**ND**	**P**[2]	**P**[2]	**ND**	**ND**	**P**[1]
Otter Creek	**260529**	**ND**	**ND**	**ND**	**ND**	**P**[1]	**ND**	**ND**	**ND**	**ND**	**ND**	**P**[1]
Jones Creek	**260531**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**P**[1]
Brights Creek	**260533**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**P**[1]
Mill Creek	**260535**	**P**[2]	**ND**	**ND**	**ND**	**P**[1]	**ND**	**ND**	**ND**	**P**[1]	**F**[1]	**P**[1]
Cowlitz (Barrier Dam to Mayfield Dam)	**260002**	**P**[2]	**NA**	**G**[2]	**P**[1]	**ND**	**F**[2]	**G**[1]	**F**[2]	**G**[2]	**F**[2]	**P**[1]

Stream Name	WRIA Index	Fish Passage	Floodplain Connect	Bank Stability	Large Woody Debris	Pool Ratio and Pools/Mile	Side Channels	Substrate Fines	Riparian Conditions	Water Quality	Water Quantity	Biological Processes
Mayfield/Tilton Basin												
Cowlitz (Mayfield Lake)	260002	**P[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	P[1]	P[1]	P[2]
Cowlitz (between Mayfield and Riffe lakes)	260002	**P[1]	ND	ND	P[1]	ND	ND	G[2]	P[1]	ND	P[2]	P[2]
Winston Creek	260541	**G[1]	ND	F[2]	P[1]	F[2]	ND	P[1]	ND	P[1]	P[1]	F[2]
Tilton River (Mayfield Lake to N. Fork Tilton)	260561	**G[1]	N/A	ND	P[2]	P[2]	ND	P[1]	P[2]	P[1]	P[2]	F[2]
N. Fork Tilton	260570	**G[2]	N/A	P[2]	P[2]	P[2]	ND	F[1]	P[2]	F[1]	P[1]	F[2]
Wallanding Creek	260576	**ND	ND	ND	ND	ND	ND	P[1]	P[1]	ND	F[1]	F[2]
Tumble Creek	260575	**P[2]	ND	P[2]	P[1]	ND	ND	ND	P[1]	G[1]	ND	F[2]
Otter Creek	260578	**ND	N/A	P[2]	P[1]	P[1]	P[1]	P[1]	P[1]	ND	P[1]	F[2]
Rockies Creek	260580	**ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	F[2]
Jesse Creek	260581	** G[1]	N/A	ND	ND	ND	ND	ND	P[1]	ND	ND	F[2]
Little Creek	260584	**ND	N/A	ND	F[1]	ND	ND	P[1]	F[1]	ND	ND	F[2]
Winnie Creek	260587	**ND	P[1]	P[1]	P[1]	ND	ND	P[1]	P[1]	ND	ND	F[2]
Lake Creek	260590	**ND	ND	ND	ND	G[1]	ND	ND	P[1]	P[2]	P[1]	F[2]
Tilton River (N. Fork Tilton to E. Fork)	260561	**G[2]	ND	ND	P[1]	P[2]	ND	P[1]	P[1]	P[2]	P[1]	F[2]
Connelly Creek	260594	**P[1]	P[1]	ND	P[1]	P[1]	P[2]	P[1]	P[1]	P[1]	P[1]	F[2]
Coal Creek	260597	**ND	ND	ND	ND	ND	ND	G[1]	*G[1]	ND	ND	F[2]
East Fork Tilton	260598	**G[1]	P[1]	F[1]	P[1]	P[1]	P[1]	G[1]	P[1]	F[1]	P[2]	F[2]
South Fork Tilton	260599	**G[1]	ND	G[2]	P[1]	P[1]	ND	P[1]	*G[1]	F[1]	P[1]	F[2]
Tilton River (E. Fork to Nineteen Creek)	260561	**G[2]	ND	P[1]	P[1]	ND	ND	P[2]	P[1]	P[2]	ND	F[2]
Nineteen Creek	260612	**ND	ND	ND	ND	ND	ND	ND	P[1]	P[1]	P[1]	F[2]
Tilton River (Nineteen Cr. to barrier falls)	260561	**G[2]	ND	ND	F[1]	G[1]	ND	P[2]	P[1]	P[1]	P[1]	F[2]
West Fork Tilton	260614	**G[2]	ND	ND	F[1]	F[1]	F[1]	P[1]	P[1]	P[1]	F[1]	F[2]
Coon Creek	260616	** G[2]	N/A	ND	P[1]	ND	ND	P[1]	P[1]	P[1]	P[1]	F[2]
Snow Creek	260617	**ND	ND	ND	P[2]	ND	ND	P[1]	P[1]	ND	ND	F[2]
Trout Creek	260619	**ND	ND	ND	ND	ND	ND	P[1]	P[1]	F[1]	ND	F[2]
Riffe Basin												
Riffe Lake		P[1]	N/A	G[2]	G[2]	N/A	P[1]	N/A	N/A	P[1]	P[1]	P[2]
Sulfur Creek	260628	P[1]	ND	ND	ND	ND	ND	ND	ND	ND	ND	P[2]
Steffen Creek	260652	P[1]	ND	ND	ND	F[1]	ND	P[1]	P[1]	ND	ND	P[2]
Frost Creek	260653	P[1]	ND	ND	ND	ND	ND	ND	P[1]	ND	ND	P[2]
Rainey Creek	260651	P[1]	P[1]	P[2]	P[1]	P[1]	P[1]	F[1]	P[2]	F[1]	P[1]	P[2]
S. Fork Rainey Cr.	----	P[1]	ND	ND	P[1]	F[1]	ND	ND	P[2]	ND	ND	P[2]

Stream Name	WRIA Index	Fish Passage	Floodplain Connect	Bank Stability	Large Woody Debris	Pool Ratio and Pools/Mile	Side Channels	Substrate Fines	Riparian Conditions	Water Quality	Water Quantity	Biological Processes
Lunch Creek	----	P[1]	ND	ND	P[1]	F[1]	ND	P[1]	P[2]	ND	P[2]	P[2]
Stiltner Creek	----	P[1]	ND	P[1]	P[1]	P[1]	ND	P[1]	P[2]	P[1]	P[2]	P[2]
Tumwater Creek	260667	P[1]	ND	ND	ND	ND	ND	ND	ND	ND	ND	P[2]
Goat Creek	260656	P[1]	ND	ND	ND	ND	ND	ND	G[1]	ND	ND	P[2]
Upper Cowlitz (Riffe Lake to Cowlitz Falls Dam)	260002	P[1]	N/A	G[2]	ND	ND	ND	ND	ND	ND	P[1]	P[2]
Cispus Basin												
Cispus River (overall)	260668	**P[1]	P[2]	P[2]	P[2]	F[2]	G[2]	F[2]	P[2]	F[2]	F[2]	P[1]
*Cispus River **(Quartz Creek to Iron Creek)***		**G[2]	P[2]	P[2]	ND	P[1]	F[2]	P[1]	P[1]	P[1]	P[1]	P[1]
Quartz Creek	260670	**G[2]	G[2]	P[2]	P[2]	F[2]	F[2]	P[2]	P[2]	P[2]	P[2]	P[1]
Crystal Creek	260690	**G[2]	G[2]	F[2]	P[2]	P[2]	G[2]	F[2]	P[2]	F[2]	G[2]	P[1]
Woods Creek	260694	**G[2]	F[2]	G[2]	P[2]	F[2]	G[2]	G[2]	F[2]	F[2]	G[2]	P[1]
Iron Creek	260697	**G[2]	F[2]	P[1]	P[1]	F[2]	G[2]	F[2]	P[2]	P[2]	P[2]	P[1]
*Cispus River **(Iron Creek to North Fork Cispus)***		**G[2]	P[2]	P[2]	F[2]	ND	P[1]	P[1]	G[2]	P[1]	G[2]	P[1]
Greenhorn Creek	260735	**G[2]	F[2]	F[2]	P[2]	P[2]	G[2]	P[1]	F[2]	F[2]	F[2]	P[1]
Yellowjacket Creek	260757	**G[2]	P[2]	P[2]	P[2]	P[2]	G[2]	P[1]	F[2]	P[2]	P[2]	P[1]
McCoy Creek	260766	**G[2]	G[2]	G[2]	P[2]	F[2]	G[2]	F[1]	P[2]	F[2]	F[2]	P[1]
Camp Creek	260860	**G[2]	P[2]	ND	ND	F[1]	ND	P[1]	P[1]	ND	F[1]	P[1]
North Fork Cispus R.	260866	**G[2]	G[2]	G[2]	P[2]	F[2]	F[2]	F[2]	G[2]	G[2]	F[2]	P[1]
Cispus River (North Fork to RM 32.5)		**G[2]	F[1]	P[2]	P[1]	F[1]	G[1]	P[1]	G[1]	P[1]	P[1]	P[1]
East Canyon Creek	260925	**G[2]	F[2]	P[2]	P[2]	P[2]	F[2]	P[2]	P[2]	P[2]	P[2]	P[1]
Orr Creek	260973	**G[2]	G[2]	G[2]	F[2]	F[2]	G[2]	F[2]	F[2]	G[2]	G[2]	P[1]
Upper Cowlitz Basin												
Cowlitz River (Cowlitz Falls to RM 115)		**G[1]	P[1]	P[1]	P[1]	P[1]	P[2]	P[2]	P[1]	G[2]	P[1]	P[1]
Lambert Creek	261015	** P[2]	ND	ND	ND	ND	ND	ND	ND	ND	ND	P[1]
Siler Creek	261018	** P[2]	G[2]	G[2]	P[2]	F[2]	P[2]	F[2]	P[2]	F[2]	F[2]	P[1]
Kiona Creek	261022	** P[1]	P[2]	P[1]	P[1]	P[1]	P[2]	P[2]	P[1]	P[1]	P[1]	P[1]
Peters Creek	261023	** P[1]	P[2]	P[1]	P[1]	P[1]	P[2]	P[2]	P[1]	P[1]	P[1]	P[1]
Oliver Creek	261025	** P[1]	ND	P[1]	P[1]	P[1]	P[2]	P[2]	P[1]	P[1]	P[1]	P[1]
Miller Creek	261028	**ND	P[2]	ND	ND	P[1]	P[2]	P[2]	ND	ND	P[1]	P[1]
Silver Creek	261031	**G[2]	P[2]	P[2]	P[2]	F[2]	F[2]	P[2]	P[2]	P[2]	F[2]	P[1]
Davis Creek	261085	** P[1]	P[2]	F[2]	P[2]	F[2]	G[2]	G[2]	F[2]	G[2]	P[1]	P[1]
Kilborn Creek	261097	** P[1]	ND	ND	ND	P[1]	P[2]	F[2]	ND	ND	P[1]	P[1]

Stream Name	WRIA Index	Fish Passage	Floodplain Connect	Bank Stability	Large Woody Debris	Pool Ratio and Pools/Mile	Side Channels	Substrate Fines	Riparian Conditions	Water Quality	Water Quantity	Biological Processes
Cowlitz River (RM 115 to Muddy Fork)		**G[1]	G[2]	G[2]	P[2]	P[1]	G[2]	F[2]	P[1]	G[2]	F[1]	P[1]
Garrett Creek	261101	** P[1]	ND	P[1]	ND	P[1]	F[2]	ND	P[1]	ND	P[1]	P[1]
Burton Creek	261105	** P[1]	ND	ND	ND	G[2]	ND	ND	P[1]	ND	P[1]	P[1]
Willame Creek	261111	** P[1]	G[2]	G[2]	F[2]	F[2]	G[2]	F[2]	F[2]	P[2]	P[1]	P[1]
Smith Creek	261127	**F[2]	P[2]	P[2]	P[2]	F[2]	F[2]	P[2]	P[2]	F[2]	P[2]	P[1]
Johnson Creek	261142	**P[2]	P[2]	G[2]	F[2]	F[2]	F[2]	G[2]	F[2]	G[2]	G[2]	P[1]
Hall Creek	261174	**G[2]	P[2]	G[2]	F[2]	F[2]	F[2]	F[2]	P[2]	F[2]	P[2]	P[1]
Skate Creek	261182	**G[2]	P[2]	F[2]	P[2]	F[2]	F[2]	F[2]	P[2]	G[2]	F[2]	P[1]
Butter Creek	261205	**G[2]	P[2]	G[2]	F[2]	F[2]	F[2]	F[2]	P[2]	G[2]	F[2]	P[1]
Lake Creek	261231	**F[2]	F[2]	F[2]	F[2]	G[2]	F[2]	F[2]	F[2]	G[2]	G[2]	P[1]
Coal Creek	261263	**G[2]	F[2]	F[2]	F[2]	F[2]	F[2]	F[2]	F[2]	G[2]	G[2]	P[1]
Muddy Fork Cowlitz	261275	**G[2]	G[2]	G[2]	G[2]	F[2]	G[2]	G[2]	G[2]	G[2]	G[2]	P[1]
Ohanapecosh River	261304	**G[2]	G[2]	G[2]	G[2]	G[2]	G[2]	G[2]	G[2]	G[2]	G[2]	P[1]
Clear Fork Cowlitz	261398	**G[2]	G[2]	G[2]	G[2]	G[2]	G[2]	G[2]	G[2]	G[2]	G[2]	P[1]

P = "Poor" as defined in Appendix B (Salmonid Habitat Condition Rating Standards)
F = "Fair" as defined in Appendix B (Salmonid Habitat Condition Rating Standards)
G = "Good" as defined in Appendix B (Salmonid Habitat Condition Rating Standards)
NA = Not applicable to this area.
ND = Habitat Conditions are Unknown
1 = Literature source
2 = TAG
* = Shaded, but lacking conifers (natural condition).
** Trap and haul passage only

General Recommendations for WRIA 26

There were a number of recommendations that were not specific to individual subbasins and that apply across the entire WRIA including:

- The series of dams on the Cowlitz River system limits access to approximately 80% of the historic anadromous distribution. Continued mitigation for the impacts of the dams on salmon, steelhead, and coastal cutthroat populations and continued assessment of the success of the reintroduction efforts will be critical to recovery of wild salmonids within WRIA 26.
- Various land uses practices have substantial impacts on habitat conditions for anadromous salmonids. The TAG suggests that critical areas ordinances be developed and/or updated to ensure protection of habitat for threatened and endangered species.
- Assess, repair, and where possible, decommission roads that are contributing chronic sediment to stream systems or that may fail and lead to landslides, especially within areas with road densities above 3.0 miles/square mile.
- Look for opportunities, both short- and long-term, to increase Large Woody Debris (LWD) supplies within stream systems. Almost every stream system within WRIA 26 has concentrations of LWD that are below standards. Supplementation of LWD can help collect spawning gravels, enhance pool habitat, create habitat diversity and cover for salmonids, and stabilize stream channels.
- Riparian restoration is needed almost throughout WRIA 26. However, many areas are in the process of recovering and now contain early successional deciduous species that at least provide some shade and other riparian functions. Long-term goals should include speeding the recruitment of mature conifers within these riparian areas.
- Look for ways to reduce excessive water temperatures in WRIA 26, especially within the Coweeman, Toutle, and Tilton Subbasins.
- In general, look for ways to augment stream flows in WRIA 26 during low-flow periods. Initial analysis of available salmonid habitat at various stream flows within the stream systems of WRIA 26 shows that habitat is often limited during low-flow periods in the summer and early fall (Caldwell et. al. 1999).

Coweeman River Subbasin Assessment

Access

There are a number of blocking culverts within the Coweeman subbasin that need assessment and then prioritization for replacement or repair. Turner Creek, with approximately 2.4 miles of potential habitat above the blocking culvert is the most significant barrier identified within the subbasin (see Table 8). TAG members noted that culverts upstream of the Turner Creek culvert at Rose Valley are being upgraded now, assuring full access to upstream habitat.

Floodplain Connectivity

- Where possible, look for opportunities to reconnect floodplain habitat to streams within the Coweeman subbasin. The Coweeman River and lower Cowlitz River have very limited rearing and overwintering habitat remaining due to diking and filling of floodplain wetlands with sediments from Mt. Saint Helens. Between RM 4 and RM 7.5 on the Coweeman River is some of the only remaining unconfined rearing habitat within this subbasin (TAG). Enhancement of off-channel habitat within this reach could provide multiple benefits for multiple species.
- The abandoned gravel ponds and other off-channel areas near RM 7 on the Coweeman River could potentially provide important rearing and overwintering habitat for juveniles if they were connected to the river. This proposal would need careful assessment to make sure that reconnecting these ponds would not negatively impact salmonid survival (see Norman et. al. 1997 for recommendations on turning abandoned gravel ponds into rearing habitat).
- Development is rapidly occurring on floodplain wetlands and other critical habitats within the lower Cowlitz River that was filled with sediments from Mt. Saint Helens. Cowlitz and Lewis counties should look for opportunities to protect and if possible enhance floodplain habitat along the mainstem Cowlitz and/or the lower reaches of Cowlitz River tributaries. Once development occurs on floodplain habitat there will be fewer opportunities for future enhancement of this critical habitat, and restoration will become extremely expensive.

Streambed Sediment Conditions

WDW (1990) and TAG members noted that sedimentation and gravel quality are habitat constraints on the production of coastal cutthroat, winter steelhead, fall chinook, and coho within the Coweeman subbasin. Fine sediment is apparent in the channels of the Coweeman subbasin as a chocolate brown storm flow and fine sediment accumulates on channel margins, in backwater areas, and in side channels (Weyerhaeuser 1996). High background sediment delivery rates combined with splash damming, past logging practices, poor riparian conditions, extremely high road densities, and over 69 miles of valley bottom roads all contribute to the excessive fine sediment loads.

Recommendations for addressing fine sediments include:

- Road densities within the subbasin are extremely high with numerous stream-adjacent (valley bottom) roads. Cowlitz County, Weyerhaeuser, and other large property owners should continue efforts to assess, repair, and/or abandon road systems that are contributing sediment to streams.
- Rose Valley Road contributes an estimated 351 metric tons/year to adjacent stream systems, or 11% of the total estimated input of fine sediment from roads in the upper watershed (Weyerhaeuser 1996). Cowlitz County needs to assess the condition of Rose Valley Road, and look for ways to reduce fine sediment delivery to anadromous streams from this chronic source.
- The 1600 Road and 1680 Road also contribute 94 and 50 metric tons/year respectively to streams in the upper Coweeman subbasin (Weyerhaeuser 1996).

- The weathered parent material within the subbasin results in generally high background sediment delivery rates. Reduce the level of harvest and road construction in areas where they might exacerbate already high background sediment delivery rates.

Channel Conditions

- Habitat diversity within the lower mainstem Cowlitz and Coweeman rivers has been significantly reduced by diking and channel simplification, the loss of riparian function, reduced LWD inputs, channel dredging, and excessive sediment inputs from Mt. Saint Helens. Look for opportunities to enhance habitat diversity within the lower mainstems of both the Cowlitz and Coweeman rivers.
- Along the mainstem Coweeman from RM 4 to RM 7.5, agriculture is the dominant land use and bank stability is poor. This is one of the few remaining areas within the basin with an unconfined channel and the potential to provide additional rearing habitat for juveniles (TAG). Look for opportunities to partner with landowners in restoring the riparian vegetation and fencing cattle out of riparian zones.
- On the upper Coweeman from approximately RM 17 to RM 26 the parent material is weak and removal of lateral support, often by the stream channel, results in frequent small mass failures and bank erosion. This results in local high sediment delivery to steam channels (Weyerhaeuser 1996). Avoid land-use activities that can aggravate this natural instability, and restore coniferous riparian vegetation to slow this natural process.
- LWD is important for pool formation within most of the upper Coweeman watershed, and it is generally lacking throughout this area (Weyerhaeuser 1996). According to the Upper Coweeman watershed Analysis (Weyerhaeuser 1996), most of the fish-bearing channels in the upper Coweeman would respond to increased loading of LWD by forming pools and steps, and trapping sediments. The exception might be the high-energy systems such as the Coweeman mainstem and some larger tributaries like Mulholland and Baird creeks. Sites for placement of LWD should be chosen only after careful consideration of the potential success of the project.
- Minimize the amount of clear-cutting that is occurring within the basin at any one time, as well as reduce the road density. Extensive clear-cutting (Chamberlin et al. 1991) and high road densities (Furniss et al. 1991) potentially increase peak flows within a basin, which may contribute to structural changes in the channel form, increase channel instability, and increase sediment delivery to the stream.
- Residential development, along with substantial bank hardening, is occurring along many of the stream systems within the subbasin (Ostrander, Owl, and upper Salmon creeks were mentioned by the TAG). Minimize placement of residential development within riparian corridors, and use updated streambank protection guidelines wherever possible to maintain habitat diversity and reduce upstream and downstream impacts from bank protection.

Riparian Conditions

- Almost all of the lower mainstem Cowlitz and Coweeman rivers have poor riparian conditions due to extensive diking, fill placement, residential and commercial

development, and agricultural activities. Work with the diking districts, Cowlitz County, Cowlitz County Conservation District, and private landowners to develop riparian management plans that can increase riparian function within these lower reaches.
- Riparian function is reduced along over 69 miles of valley bottom roads within the subbasin. Look for opportunities to abandon or at least restore functioning riparian conditions along valley bottom roads in the subbasin.
- Replant degraded riparian areas with native conifers to help reduce sediment delivery to streams, provide shade and reduce water temperatures, and speed recruitment of conifers for a future supply of LWD. To begin with, focus riparian restoration efforts along the more productive tributaries including Baird, Mulholland, and Goble creeks.

Water Quality
- Address land use activities within the subbasin that contribute to water quality problems (especially temperature). Specifically, maintain adequate riparian area along all stream systems to buffer streams from adjacent land uses, fence livestock away from riparian areas, replant degraded riparian areas with native conifers and shrubs, and reduce road densities and impervious surfaces.
- Efforts to restore water quality in the subbasin should be focused on some of the most productive tributaries that also have existing water quality problems including Baird, Mulholland, and Goble creeks.

Water Quantity
- Both Salmon and Ostrander Creeks have potentially significantly reduced fish production because of low flows (Caldwell et. al. 1999). Look for opportunities to augment late summer flows to enhance spawning and rearing habitat within Salmon and Ostrander creeks.

Biological Processes
- Escapement for most anadromous stocks in the Coweeman subbasin is well below average (WDF et. al. 1993: LCSCI 1998), and the lack of carcasses contributing nutrients to the systems may be limiting production within the subbasin. Carcass placement projects are ongoing in some lower Cowlitz River subbasin tributaries, but not within the Coweeman subbasin. Assess the possibility of placing salmon carcasses in various stream systems within the subbasin.

Toutle River Subbasin Assessment

Access
- One of the most significant factors limiting fish passage within the Toutle subbasin is the problem operating the fish collection facility when heavy sediment loads are moving through the Sediment Retention Structure (SRS) on the North Fork Toutle. With the SRS in place, natural recovery of the stream system is precluded, and heavy

sediment loads will likely continue to affect fish passage for an indeterminate amount of time. Assessment and repair of this situation is critical to the recovery of Toutle River populations of anadromous salmonids.
- Assessment and, if possible, alterations on to the Silver Lake Dam to increase flows in Outlet Creek is necessary to assure fish passage into the Silver Lake watershed.
- There are a number of blocking culverts within the Toutle River subbasin that need assessment and then prioritization for replacement or repair. One of the more significant culverts to assess and repair is on North Fork Wyant Creek where a culvert blocks passage at the 4531 Road crossing. The TAG considered repairs a high priority because this is a productive coho stream.

Floodplain Connectivity

- Where possible, look for opportunities to reconnect and enhance floodplain habitat within the Toutle River subbasin. Large sediment loads still move through the Toutle and its tributaries, reducing the amount and quality of pool habitat and other areas where fish might seek refuge during high flows. Floodplain and off-channel habitat, especially where there is adequate cover, might be especially critical refuge for juveniles attempting to rear in this disturbed system.

Streambed Sediment Conditions

- Annual sediment discharges in the North Fork had not changed appreciably 5 years after the eruption of Mount St. Helens (Lucas 1986), and Tag members felt that fine and suspended sediments were still a major limiting factor in the North Fork and mainstem Toutle Rivers. TAG members stated that the Sediment Retention Dam (SRD) on the North Fork was the major obstacle preventing natural recovery of both the North Fork and the mainstem Toutle downstream. As it exists, the SRD has just become a major chronic fine sediment source to downstream habitats (TAG). Removal or alteration of the SRD would allow for the eventual recovery of the North Fork and downstream systems.
- Road densities within the subbasin are extremely high with numerous stream-adjacent (valley bottom) roads. The lower Green River, South Fork Toutle, and Silver Lake watershed have some of the highest road densities. Efforts should continue to assess, repair, and/or abandon road systems that are contributing fine sediment to streams.
- Many of the road systems within the upper South Fork Toutle subbasin are now inaccessible due to the eruption and are likely in need of maintenance and repair. Assessment and maintenance of these roads is needed.
- Spawning substrates are limited within areas of the Silver Lake watershed. LWD placement and/or channel enhancements are needed to capture sparse gravels.

Channel Conditions

In general, most stream systems within the upper Toutle River subbasin are recovering from the effects of the Mount St. Helens eruption. Channel and bank stability has increased as sediment loads have decreased and riparian conditions have improved (Jones and Salo 1986). The percentage and quality of pool habitat has increased as streams channels adjust to new conditions, especially where debris occurs (Lucas 1986).

However, with poor riparian conditions and a limited amount of LWD and cover in most streams in the subbasin, pool habitat and habitat diversity in general may be a limiting factor for many years into the future (Lucas 1986; Jones and Salo 1986).

- Look for opportunities to enhance pool habitat and habitat diversity in general through placement of LWD in appropriate stream systems.
- WDF (1993) states that the basin is hydrologically immature due to effects of the eruption and to the extensive pre- and post- eruption logging. As such, the streams are likely subjected to increase peak flows that can cause bed and bank scour and channel shifting to the detriment of egg and fry survival (WDF 1993). Minimize the amount of clear-cutting that is occurring within the basin at any one time, as well as reduce the road density. Extensive clear-cutting (Chamberlin et al.1991) and high road densities (Furniss et al. 1991) may increase peak flows within a basin, which may contribute to structural changes in the channel form, increase channel instability, and increase sediment delivery to the stream.

Riparian Conditions

- Lack of riparian cover is considered to be one major causes of elevated stream temperatures in many of the upper Toutle River subbasin including along the Green River (Haapala 1997; USFS 1994; Lucas 1985), Elk Creek (Lucas 1986), Bear Creek (Lucas 1986), North and South Forks of the Toutle, and Herrington Creek (TAG). Replant riparian areas with native conifers to provide shade and reduce water temperatures, to help reduce sediment delivery to streams, and to speed recruitment of conifers for a future supply of LWD.
- Riparian function is reduced along almost 79 miles of valley bottom roads within the subbasin. Look for opportunities to abandon or at least restore functioning riparian conditions along valley bottom roads in the subbasin.

Water Quality

- Address land use activities within the subbasin that contribute to water quality problems (especially temperature). Specifically, maintain functioning riparian areas along all stream systems to buffer streams from adjacent land uses, fence livestock away from riparian areas, replant degraded riparian areas with native conifers and shrubs, and reduce road densities and impervious surfaces.
- Efforts to restore water quality in the subbasin should be focused on some of the most productive tributaries that also have existing water quality problems including the South Fork Toutle, Green River, and Hoffstadt and Elk creeks.
- Unlike the South Fork and Green River, turbidity and suspended sediments below the Sediment Retention Structure (SRS) on the North Fork Toutle are still extremely high during freshets (TAG; Loch and Downing 1990). TAG members attributed these water quality problems to the construction and operation of the SRS. Assessment and repair of this situation is critical to the recovery of Toutle River populations of anadromous salmonids.

- Water quality problems within Silver Lake, especially within Outlet Creek, likely limits production of anadromous salmonids within the watershed (TAG; Weyerhaeuser 1994).

Water Quantity

- Both USFS (1997) and WDF (1993) note that areas of the Toutle subbasin are hydrologically immature due to effects of the eruption and to the extensive pre- and post- eruption logging. As such, the streams are likely subjected to increased peak flows that can cause bed and bank scour and channel shifting to the detriment of egg and fry survival (WDF 1993). Maintain at least 60% of the subbasin in at least 25-year-old stands.
- Outlet Creek had the most serious low flow problems within the Silver Lake watershed. Low to non-existent summer flows in Outlet Creek limit available pool habitat and coupled with high stream temperatures (July stream temperatures measured at 23° C) this creates rearing conditions that are unfavorable or lethal to juvenile salmonids (Weyerhaeuser 1994). Also, low flows and temperature barriers in Outlet Creek hinder access for anadromous salmonids into the entire Silver Lake watershed.

Biological Processes

- Escapement for most anadromous stocks in the Toutle subbasin is well below average (WDF et. al. 1993: LCSCI 1998), and the lack of carcasses contributing nutrients to the systems may be limiting production within the subbasin. Carcass placement projects are ongoing in some lower Cowlitz River subbasin tributaries, but not within the Toutle subbasin. Assess the possibility of placing salmon carcasses in various stream systems within the subbasin.
- Predation and competition from other fish species potentially limits the production of salmon and steelhead within the Silver Lake watershed (Weyerhaeuser 1994). There are approximately 25-30 fish species within the watershed, and approximately one-half are non-native fishes introduced to provide a warm-water fishery. Assess the level of predation on anadromous salmonids in the Silver Lake watershed, and look for ways to minimize the impact of non-native species.

Lower Cowlitz Subbasin Assessment

Access

The most significant passage barriers in this subbasin are the Barrier Dam at RM 49.5 and Mayfield Dam at RM 52. These blockages limit access to 80% of the historic steelhead (WDF et. al. 1993), and 96% of the historic, productive spring chinook habitat within the Cowlitz watershed (Easterbrooks 1980). A culvert survey that is presently underway should provide considerably more information on other passage problems within the subbasin by the end of 2000. Other significant passage barriers in the Lower Cowlitz subbasin that need assessment and/or repair include:

- Repair a partial barrier in the lower end of Monahan Creek, which at low flows blocks 4.8 miles of some of the best habitat in the subbasin (TAG).
- Properly maintain the Monahan Creek fish ladder. The ladder is frequently clogged with debris (TAG).
- Correct the culvert at RM 0.1 on Tucker Creek (Delemeter tributary) that blocks 0.8 mile of anadromous habitat (CCD 1995).
- Correct 6 partially blocking culverts on the mainstem of Leckler Creek. The lower-most culvert partially blocks 19,000 feet of salmonid habitat (CCD unpublished).
- Correct the culvert in Foster Creek at the Interstate 5 crossing (RM 1.5). It blocks approximately 2.0 miles of habitat. Replacement is scheduled in 2000 (Lewis County 1997).
- Assess the possibility of a fish-passage facility at the Ferrier Creek dam at RM 0.3, which blocks 1.5 miles of potential habitat (TAG).
- Whittle Creek has three blocking culverts that need assessment and repair.
- Skook Creek has two culverts at Howe Road (RM 1.1) that block approximately 4 miles of anadromous fish habitat (David Evans and Associates 1998). The quality of the available habitat above these blockages needs assessment.
- Look for ways to pass fish above the dam on Mill Creek. This impassable, hydroelectric dam, just over one mile from the mouth, blocks approximately 5.2 miles of anadromous fish habitat (TAG).

Floodplain Connectivity

Most of the lower Cowlitz mainstem (below RM 20) has been diked and channelized. Wherever possible it will be very important to preserve and/or enhance off-channel, floodplain, and side-channel habitat. In the Cowlitz mainstem, from RM 20 to RM 49, efforts should be considered to preserve functioning side channels and restore others (Harza 2000). These areas provide critical rearing and spawning habitat for fall chinook and steelhead.

Table 50: Side channel locations and recommendations in the lower Cowlitz River (Harza, 2000).

Side Channel	Recommended Action	Comment
RM 49	No action	Inflow cut off by gravel accumulation below Barrier dam; hydrologic connection through backwater inflow
RM 47	Protect from development; enhance with LWD; provide flows greater than 2,140 and less than 5,000 cfs	Important chinook spawning habitat
RM 45.3	Protect from development	Former meander; inflow and outflow apparent at 2,850 cfs
RM 45	No action	Backwater refuge at point-bar tail
RM 43.5	Protect and maintain (Tacoma power ownership); discourage use of recreational vehicles	Two wetland ponds near Brim Road; recreational vehicle use observed on vegetating gravel bar just upstream
RM 43	Protect from development; enhance with LWD; provide flows greater than 2,140 and less than 5,000 cfs	Important chinook spawning habitat.

Side Channel	Recommended Action	Comment
RM 42	Consider reconnecting ponds to side channel flow; provide flows greater than 2,140 and less than 5,000 cfs	Stagnate ponds with high, rearing-habitat potential near side channel; inflow not connected except at high flows
RM 39.7	No action	Historic meander bend; inflow cut off' good backwater inflow
RM 38-40	Protect from development and consider enhancement to reconnect backwater inflow; enhance with LWD	Historic meander bend and side channel presently subject to clearing and road building; outflow has shallow connection to potential rearing habitat
RM 37.5	No action	Historic meander bend; inflow cut off; some high - flow recharge and backwater inflow; difficult to maintain enhancement
RM 36.7	No action	
RM 35.5	Protect from development and livestock	No inflow surface connection; good backwater connection and some tributary inflow; livestock grazing concerns
RM 33	Protect from development; enhance with LWD; provide flows greater than 2,150 and less than 5,000 cfs	Potential spawning habitat
RM 32	Protect from development; enhance with LWD; provide flows greater than 2,150 and less than 5,000 cfs	Good spawning and rearing habitat
RM 31.5	Protect from development; improve backwater inflow	Former meander bend is well vegetated; side-channel inflow at high flow; consider improving outflow by removing silt accumulations
RM 30.5 Left	No action	Wide, shallow habitat with little available cover during study flows
RM 30.5 Right	Maintain inflow connectivity; protect from development; provide flows greater than 2,140 and less than 5,000 cfs	Deep pools and good shading, excellent rearing habitat
RM 27.7	Protect from development; provide flows greater than 2,140 and less than 5,000 cfs	Good shading, excellent rearing habitat
RM 24	Improve backwater inflow; protect from development	Old railroad-grade berm
RM 23	No action	High recreation use with vehicles on gravel bar

Adapted from Harza 2000

- Other tributaries with floodplain habitats that have been channelized and incised include the lower reaches of Westover, McCorkle, Leckler, Arkansas, Delameter, Olequa, Salmon, and Whittle creeks. Where possible look for opportunities to restore natural channel patterns and reconnect historic floodplains.

Streambed Sediment Conditions

- The mainstem dams reduce the supply of spawning gravel to downstream reaches of the mainstem Cowlitz. In the reach between Barrier Dam and the Cowlitz Trout Hatchery, transport capacity exceeds gravel input, and the majority of this reach lacks gravel-sized sediment (Harza 1999c). Continue to assess the sediment conditions within the mainstem and look for opportunities to supplement spawning gravels in strategic areas.
- Livestock access to tributary streams within the Lower Cowlitz Subbasin contributes to excessive fine sediments in stream channels. Limit livestock access to streams in

general but focus on the following areas: below Cline Road on Delemeter Creek, in Arkansas Creek from the mouth to the Arkansas/Baxter Creek confluence, in the agricultural areas of Leckler Creek, and in Whittle Creek from 3500 feet to 7000 feet above the mouth (TAG).
- Road densities are high within this subbasin (4.94 miles of road/square mile). Properly maintain and repair or decommission roads in the subbasin, especially in upper Arkansas Creek watershed (CCD 1995).

Channel Conditions

- There are a number of tributaries within the subbasin where agriculture and grazing has had substantial impacts on bank stability. Look for opportunities to fence cattle out of riparian areas, especially along Leckler, lower Delameter, Whittle, and Foster creeks.
- LWD concentrations within the mainstem Cowlitz and tributaries in this subbasin are considered "poor", based on observations by TAG members. Stream-survey data for the Arkansas watershed, Leckler Creek, and Whittle Creek also rated LWD as poor (CCD, 1995). Cowlitz Conservation District habitat stream surveys in the mid- and late-1990s showed poor pool frequencies in Leckler, Arkansas, Delameter, Monahan, Tucker, Baxter, and Whittle creeks. LWD is the principal pool-forming agent in many of these systems. Supplement LWD in stream reaches where the placement will help develop pool habitat and add to habitat diversity.
- Residential development, along with substantial bank hardening, is occurring along many of the stream systems within the subbasin. Minimize placement of residential development within riparian corridors, and use updated streambank protection guidelines wherever possible to maintain habitat diversity and reduce upstream and downstream impacts from bank protection.

Riparian Conditions

- Riparian conditions throughout the subbasin are generally poor. Replant degraded riparian areas with native conifers to help reduce sediment delivery to streams, provide shade and reduce water temperatures, and speed recruitment of conifers for a future supply of LWD. To begin with, focus riparian restoration efforts on some of the more productive streams including Monahan, upper Delameter, and upper Olequa. Other streams where riparian conditions need immediate attention include lower Arkansas, Leckler, Whittle Creek, Stillwater, and Lacamas creeks (CCD 1995; TAG).

Water Quality

- Address land use activities within the subbasin that contribute to water quality problems (especially temperature) within many of the tributaries. Specifically, maintain adequate riparian area along all stream systems to buffer streams from adjacent land uses, fence livestock away from riparian areas, replant degraded riparian areas with native conifers and shrubs, and reduce road densities and impervious surfaces.

- Efforts to restore water quality in the subbasin should be focused on some of the most productive tributaries that also have existing water quality problems including Olequa, Delameter, Arkansas, Lacamas and Leckler creeks.
- Address fecal coliform contamination by controlling livestock access to streams and identifying and repairing failed septic systems in Delemeter, Tucker, and Monahan creeks (CCD 1995).
- Several small tributaries to Olequa Creek flow through or near several Christmas-tree farms, which is the primary commercially grown crop in the area. Water quality samples, taken in 1995, found the highest concentrations of Atrazine yet recorded by Washington State Pesticide Monitoring Program. Reduce the use of pesticides in silvaculture applications in areas adjacent to Olequa Creek.

Water Quantity

- Continue to assess the potential impacts to all anadromous salmonids from the altered hydraulic regime caused by the operation of the dams.
- Leckler, Olequa, Lacamas, and Salmon creeks had estimated flow levels during summer and early fall that are far below optimal for spawning and rearing conditions (Caldwell et. al. 1999). Look for ways to augment low summer flows and provide additional rearing habitat within these streams.
- Encourage wetland development in areas of upper Arkansas Creek for hydrologic buffering, stream-energy dissipation, and sediment storage (CCD 1995).
- Preserve the wetland areas in lower Whittle Creek to help lessen peak flows and flooding (TAG).
- Maintain at least 60% of the land cover of the subbasin in trees greater than 25 years old.

Biological Processes

- Escapements for most anadromous stocks in the lower Cowlitz subbasin are well below historical conditions (WDF et. al. 1993; LCSCI 1998), and the lack of carcasses contributing nutrients to the systems may be limiting production within the subbasin. Assess the possibility of placing additional salmon carcasses in various stream systems within the subbasin.
- Continue to assess and reduce the impacts to wild salmonids from competition interactions and disease transmission with hatchery fish.

Tilton/Mayfield Subbasin Assessment

Access

- Reintroduction efforts in the entire subbasin are dependent upon success of downstream migration. It will be critical to the recovery of anadromous fish in this subbasin that downstream migration success continues to be monitored and improved over time.

- Culvert survey information regarding fish blockage is generally not available in the Winston Creek and Tilton River watersheds, so conditions are largely unknown. Murray Pacific (1993, 1994) estimated that nearly two-thirds of the culverts in the Connelly Creek watershed are obstructed, that in the East Fork and South Fork Tilton rivers, 24 of 31 culverts were undersized to pass a 50-year peakflow with rain-on-snow enhancement. Since over half of the subbasin is in privately owned commercial forestry, it is likely that many surveys are either ongoing or will be completed within the next 5 years to meet Fish and Forests rules. These culvert inventories are needed before priorities can be established within these watersheds.

Floodplain Connectivity

- There are 29 miles of stream adjacent roads along 33% of the anadromous stream in the subbasin (Lewis County GIS 2000). In some areas it is apparent that these roads reduce connection to historic floodplain habitat within the subbasin. Loss of floodplain rearing habitat, combined with the elevated peak flows that this subbasin experiences, likely reduces juveniles rearing success in this subbasin. Road locations, crossing, and other floodplain constrictions should be upgraded wherever possible to restore and enhance floodplain connectivity.

Streambed Sediment

- Reduce road densities in the subbasin from approximately 4.88 miles of roads/square mile to the range of 2-3 miles per square mile, with priorities to decommission roads that increase the drainage network. Avoid road construction in areas identified as prone to mass wasting.
- Prevent and minimize road drainage problems near the mainstem Connelly Creek, and in upper reaches in the headwaters (Section 17) and in Section 21 (Murray Pacific 1996).
- Close or decommission roads identified in the USFS Travel and Management Plan for the areas of the Tilton subbasin within the Gifford Pinchot National Forest (EA 1998).

Channel Conditions

- TAG members felt that almost the entire subbasin was lacking in quality LWD. LWD placement could provide instream structure and cover, and enhance pool quality and spawning habitat. However, elevated peak flows are a major problem within most of the subbasin, and careful assessment of the hydraulics of the site as well as the hydrology of the basin is needed to assure success with LWD placement projects.
- With a general lack of LWD, quality pool habitat, and side-channel habitat, juveniles are unable to find cover and are often flushed out of the Tilton into Mayfield Lake. Fry are often found at the dam after high flows. Look for opportunities to restore and/or enhance side- and off-channel rearing habitat that will provide refuge during high flows.

- LWD placement projects in Connelly Creek are not recommended until management programs in mass wasting and riparian areas have a chance to take effect, which may take decades (Murray Pacific 1996).

Riparian Conditions

- With over 40% of the riparian corridor in ‘poor” condition, and over 46% in an early-seral stage (Lewis County GIS 2000), it will be important to establish functioning riparian corridors within the subbasin. There may be adequate shading along some stream systems, but there are not enough conifers within the riparian zones to provide for recruitment of LWD. Expedite development of large-tree riparian structure within 150-foot wide riparian zones in the subbasin through silvacultural treatments. Goals to achieve would include > 70% mature conifers in riparian zones, preferably western red cedar, Sitka spruce, and western hemlock in the valley bottoms and Douglas fir in the uplands.
- Increase riparian shade by planting trees along Connelly Creek and its major tributaries (Murray Pacific 1996), and along the riparian areas detailed in the West Fork/Nineteen Creek Watershed Analysis (Murray Pacific 1998), and East Fork Tilton Watershed Analysis (Murray Pacific 1994)
- Because of the checkerboard pattern of national forest and private ownership, the USFS has prioritized the improvement of riparian areas and aquatic conditions in the Wallanding Creek and Tumble Creek watersheds. In upper Wallanding Creek create large-tree structure adjacent to upland, wetland habitat (EA 1998).
- Look for opportunities to increase bank stability in the East Fork Tilton, North Fork Tilton, and Winston Creek by restoring the riparian plant community.
- Riparian buffer areas should be fenced to reduce livestock impacts throughout the subbasin.

Water Quality

- Water quality monitoring has recorded numerous elevated water temperatures in the Tilton River and its tributaries. Loss of riparian canopy has likely been the major contributor to this water quality problem. Wherever possible, restore the riparian plant community to increase stream shading. For future management, maintain adequate riparian buffers to provide good shading as well as filter contaminants from upslope activities.
- Peak stream temperatures in Connelly Creek have exceeded acceptable levels for fish habitat in the four years of temperature monitoring. Readings occasionally exceeded 22°C in the lower reach. Peak temperatures and stream shading data suggest that lack of shade is the dominant factor influencing peak stream temperatures in this watershed (Murray Pacific 1996).
- Turbidity is a substantial problem within the Tilton River and within Mayfield Lake. Future land management goals should look to reduce road densities, upgrade roads and road crossings, and reduce timber harvest and other activities within riparian zones that alter riparian functions and contribute sediment to stream systems.

Water Quantity

- Elevated peak flows appear to be a significant problem within the Tilton River and most of its major tributaries. Stream systems are often scoured of most spawning substrates, channels are altered, and juvenile attempting to rear in the system are flushed into Mayfield Reservoir. Elevated peak flows are attributed to extensive timber harvests that have reduced the hydrologic maturity of many watersheds. The cumulative impacts from timber harvests should be addressed to assure that at least 60% of the vegetative cover in a watershed is in trees greater than 25 years old.
- Roads can extend the drainage density within a watershed, and alter the timing and magnitude of peak flows (Furniss et. al. 1991; Harr et. al. 1975). High road densities within the subbasin also likely contribute to increased peak flows. Reduce overall road densities, with prioritization of stream adjacent roads and roads that extend the drainage network. Road drainage systems can also be altered to increase infiltration and reduce the amount of water delivered immediately to streams.
- Low summer flows in the North, South, East, and West forks of the Tilton cause severe degradation of habitat with an average low-flow depth of less than 1 foot (Harza 1997b). Also, in comparing the optimal toe-width flows to spot flow measurements, Caldwell et. al. (1999) found that Winston Creek had flow levels on August 31, and October 3 that were far below optimum for spawning and rearing conditions. Look for opportunities to reduce withdrawals and augment flow during summer and early fall low-flow periods.
- Fish farming within the subbasin has the potential to negatively impact water quality and should be closely monitored.

Biological Processes

- With the release of 7,800 adult male and female coho in the Tilton River watershed nutrients are likely being distributed widely throughout the subbasin. At least this level of stocking should be continued to assure adequate distribution of nutrients to support aquatic communities within the subbasin.
- Predation may be a significant problem for juveniles migrating through Mayfield Lake. As part of the reintroduction efforts the effects of predation should continue to be monitored and potential solutions should be developed.
- The importation and farming of Atlantic salmon within the Tilton River raises the risk of disease exposure and other potential impacts to wild fish and its effects should be closely monitored.

Riffe Lake subbasin Assessment

Access

Access through the dams and downstream migration are the major limiting factors within the subbasin. Until the downstream migration problems can be fixed, and capture efficiency at the dams can be increased, reintroductions of anadromous fish into the basin will be unsuccessful. Therefore, it is unlikely in the near future that the Riffe Lake subbasin will be anything other than a resident fishery. If coastal cutthroat trout are listed, the Riffe Lake subbasin could become an important subbasin for resident and adfluvial forms of coastal cutthroat trout. However, considering the existing condition, habitat enhancement and/or protection within the basin should be a low priority for funds intended to benefit anadromous fish stocks.

Cispus Subbasin Assessment

Access

- Reintroduction efforts in the entire subbasin are dependent upon successful operation of the Cowlitz Falls Fish Collection Facility. It is critical to the recovery of anadromous fish that capture efficiency at the dam is monitored and improved over time.
- Only one blocking culvert was identified in the upper reaches of Woods Creek. However, there are passage problems occurring due to subsurface flow in Copper Creek, Crystal Creek, and Camp Creek. Aggradation of the channels has contributed to this problem, and land use practices have likely increased the sediment supply and contributed to aggradation. Maintain adequate riparian buffers, reduce road densities, continue with plans to decommission and repair several stream adjacent roads.

Floodplain Connectivity

- Off-channel rearing habitat is limited within the subbasin. Floodplain connectivity has been reduced by stream adjacent roads along the mainstem Cispus between Quartz and Iron creeks, in Yellowjacket Creek, along the alluvial fan of Camp Creek, and to a lesser extent on the mainstem Cispus between Iron Creek and the North Fork Cispus. The USFS has been addressing many of these road related problems, and it should continue to move ahead with its plans to decommission or move roads that reduce floodplain connectivity and limit rearing habitat (TAG; USFS 1996a and 1996b).
- Where possible look for opportunities to enhance existing off-channel habitat by supplementing LWD to increase cover and habitat diversity (TAG).

Streambed Sediment Conditions

- Fine sediment inputs exceed natural levels in many areas of the subbasin. Fine sediment accumulations are a major concern in Greenhorn, Yellowjacket, and McCoy creeks, and in the Cispus River above Quartz Creek. Fine sediments are also causing embedded substrates in spawning grounds in the North Fork Cispus and in mainstem Cispus above the North Fork confluence (USFS 1995). Reduce road densities where possible and reduce fine-sediment delivery from roads to streams with sediment traps, filters, erosion-control blankets, and by minimizing use of fine materials in constructing stream crossings (USFS 1996a).

- Stabilize mass wasting to reduce coarse-sediment delivery in Camp Creek watershed (USFS 1996b).
- Stabilize mass wasting areas along Greenhorn Creek with riparian plantings (USFS 1996b).
- Plant trees along braided section of Cispus River between Yellowjacket (RM 17.4) and Blue Lake (RM 25) creeks to increase riparian function and to increase bank stability in the reach (TAG).
- Continue to evaluate dispersed and developed recreation areas for excessive use or damage to resources (USFS 1996a and 1996b).
- Reconstruct or relocate identified trails and trail crossings over streams (USFS 1996b).

Channel Conditions

- Place LWD in response reaches of the North Fork Cispus River, Yellowjacket, Wood, and Ames creeks, and other systems that lack LWD. Utilize LWD that collects at Mossyrock Dam for projects within the Cispus subbasin (TAG).
- The TAG recommends road maintenance and decommissioning, and the use of riparian plantings in side channel areas from Iron Creek to Blue Lake Creek to reduce sediment delivery and channel instability.
- LWD placement in the lower Cispus, near the head of Lake Scanewa, would provide cover that would help attract juveniles to the area. This would help move juveniles away from the Cowlitz Falls Dam where they might be flushed into Riffe Lake during frequent drawdowns.
- Incorporate new road construction techniques that allow the passage of components such as LWD and sediment that are essential to aquatic-system function (USFS 1996a).
- Channel widening has occurred in many areas within the Cispus subbasin, likely due to cumulative upslope impacts. Recovery from past land use activities, combined with recent changes in forest harvest policy and road construction techniques by the Forest Service should help reduce sediment delivery to the channel over the long term. The Forest Service should continue to assess the impact their activities have on anadromous fish habitat, and look for opportunities to provide short-term habitat improvements within the subbasin.
- Side-channel habitat is limited and/or unstable in many areas of the subbasin. The mainstem Cispus, from Iron Creek to the North Fork Cispus, has experienced significant channel widening, indicative of cumulative sediment loading (USFS 1996b). There is potential for side-channel formation here, but the river continues to "move around a lot" creating unstable habitat conditions (TAG). Look for opportunities to increase stable side-channel habitat within this reach.
- The North Fork Cispus generally lacks side channels, tributaries, and alcoves for coho rearing (USFS 1995). Look for opportunities to help increase and/or enhance side-channel habitat within the North Fork Cispus.

Riparian Conditions

- A majority of the riparian habitat within the subbasin consists generally of early seral stage vegetation (Lunetta et. al. 1997; Lewis County GIS 2000). Manage early- and mid-structural stands within riparian reserves to develop late-structural characteristics in the Cispus subbasin. This will help increase both riparian function as well as the recruitment potential for LWD (USFS 1996a; 1996b; and 1995).
- Plant trees along braided section of Cispus River between Yellowjacket (RM 17.4) and Blue Lake (RM 25) creeks to increase riparian function and to help provide stability to the reach (TAG).
- Increase riparian shade with pre-commercial thinning, planting, and under-planting in specified areas in the Cispus River, East Canyon, and Chambers creeks (USFS 1995).

Water Quality

- While land use activities have impacted water quality within the subbasin, water temperatures in the upper Cispus watershed indicate that all streams are within the historic, natural range of variability for the Cowlitz basin. Forest Service policies that afford protection and restoration of functioning riparian zones, decommission and/or repair roads, and reduce overall upslope impacts to stream systems should be encouraged.
- For the Cispus River just above Quartz Creek, Woods Creek, and East Canyon Creek stream water temperatures are elevated and additional restoration activities are needed to reduce potential impacts to anadromous fish.

Water Quantity

- Juveniles are often flushed over the Cowlitz Falls Dam or stranded in areas due to frequent drawdowns during high flows. The flow (cfs) thresholds for drawdowns should be reevaluated with fisheries in mind, and if possible the drawdown thresholds should be increased.
- Schedule activities in upslope areas to maintain peakflows within each subwatershed at the recommended thresholds: ARP greater than 70 percent and WAR less than 10 percent. An overall threshold should be derived and followed for all subbasins within the watershed (USFS 1996a).
- Decommission roads to decrease of the miles of roads and to minimize the overall drainage network (USFS 1996a).

Biological Processes

- Carcasses and nutrients are likely well distributed throughout the Cispus subbasin by the recent level of stocking. However, this level of planting is likely well below historic escapement, and it will important to continue to stock or distribute at least this many adult fish or carcasses in the subbasin.

Upper Cowlitz Subbasin Assessment

Access

- Both upstream and downstream passage through the dams is the most significant factor limiting anadromous salmonid production within the subbasin. The reintroduction program for the upper Cowlitz and the Cispus subbasins relies on the efficiency of the fish collection facility at the Cowlitz Falls Dam. A sustainable run of anadromous salmonids can't be reestablished in the upper Cowlitz and Cispus subbasins without an efficient method to capture downstream migrants. Recently modified baffles at the fish collection facility appear to considerably improve collection efficiency. It is critical that collection efficiency monitoring at the collection facility continue, along with efforts to improve the efficiency of the collection equipment and process.
- Low-flow and subsurface flow passage problems occur in many of the upper Cowlitz River tributaries. Some of the problems are associated with channel aggradation due to excessive sediment deposition in lower gradient reaches of the tributaries. Various land-use activities have contributed to this aggradation including channelization, bank hardening, timber harvests, road construction, agriculture, and grazing. These tributaries provide critical, and limited, spawning and rearing habitat for steelhead, coho, and coastal cutthroat. Assessment of these stream systems is needed to determine which specific land-use activities are contributing to sediment deposition and to look for potential enhancement opportunities.
- Some of the steelhead released into the upper basin fall back to the Cowlitz Falls collection facility. These fish are collected and released into Kiona Creek to spawn in areas that may go dry near the time of emergence. The timing and extent of low-flow conditions within Kiona Creek should be assessed if this practice is to continue.
- A number of artificial migration barriers also need assessment and repair or replacement including:
    - Culverts on Siler, Willame, and Lambert Creeks;
    - The ponds on Siler Creek at Mt. Adams logging mill;
    - An old water diversion structure at the mouth of the canyon on Johnson Creek; and
    - Channelization of the lower ¼ mile of Smith Creek.

Floodplain Connectivity

- Substantial amounts of floodplain habitat have been lost in the upper Cowlitz subbasin. Lake Skanewa inundated 11 miles of braided channel and floodplain habitat, and the lower end of almost every tributary has been affected by diking, channelization, and/or fill placement. Look for opportunities to reconnect and/or enhance floodplain habitat within the upper Cowlitz subbasin, especially within the lower reaches of anadromous tributaries. These tributaries provide important

spawning and rearing habitat for all species, and creation or enhancement of off-channel habitats may be the highest priority project within the subbasin (TAG).
- Kiona Creek has a checkerboard pattern of ownership that has resulted in reaches of the stream that are in good shape and reaches that are channelized and degraded. The creek provides important steelhead, coho, and cutthroat trout habitat. Look for opportunities to educate and partner with landowners to increase floodplain connectivity and habitat quality on private property within the watershed.

Streambed Sediment Conditions

- The cumulative impacts of various land use practices and channel modifications have increased sediment loads and subsequently have reduced pool quality and quantity in the mainstem Cowlitz and its tributaries (USFS 1997b: Meyer et. Al. 2000: letter; Mobrand Biometrics 1999 vol.1). Sedimentation of the many key tributary channels to the upper Cowlitz basin including Kiona, Oliver, Peters, Miller, Hampton, Silver, Siler, Kilborn, Davis, Smith, Johnson, lower Lake, lower Coal, lower Butter, Skate, and both the North Fork and main stem Willame Creek limits both the quantity and quality of fish production within the upper Cowlitz River subbasin (USFS 1997a; USFS 1997b; Meyer et. al. 2000; letter). Ditching, diking, dredging, and channelization has increased water velocities in many of these channels, and thus increased the cutting action and erosion potential in the channel leading to additional problems downstream in depositional areas (USFS 1997a). Work with landowners to restore more natural channel conditions and to practice "Best Management Practices" (BMPs) to help reduce sediment delivery to stream channels.
- Road densities in the upper Cowlitz subbasin are the lowest of any subbasin in WRIA 26. However, efforts to continue to assess and repair or decommission roads within the national forest should be encouraged.
- Fence cattle out of riparian areas, where they contribute to increased fine sediment delivery by removing riparian vegetation and destabilizing streambanks.

Channel Conditions

- Farming and grazing along the portion of the banks of the mainstem Cowlitz and various tributaries also impacts channel stability and has resulted in severe erosion and a reduction in riparian habitat. Look for opportunities to work with landowners to fence cattle out of riparian areas and restore native vegetation.
- Bank instability has been noted within scattered areas of Davis Creek, the middle reaches of Silver Creek, Garrett Creek, Skate Creek, Kiona Creek, Oliver Creek, and Peters Creek. Assess, and if possible address conditions that are contributing to bank instability in these areas.
- During high flows the Cowlitz Falls Dam is required to draw down the level of Lake Skanewa and juvenile fish are often flushed downstream and lost into Riffe Lake. Increase instream cover and habitat diversity in the upper reaches of Lake Skanewa to attract fish away from the dam and reduce the chance of flushing juveniles during drawdowns.
- The lower alluvial reaches of tributaries to the upper Cowlitz provide important spawning and rearing habitat for all salmonids. Many of the lower portions of

tributaries to the upper Cowlitz have been channelized, dredged, and diked. Work with landowners to restore more natural stream conditions that would benefit fish production in these systems.

- Almost all the tributaries to the upper Cowlitz subbasin also have "poor" LWD abundance. Murray Pacific (1995) attributes the overall poor LWD abundance to past debris flows, riparian clearing, active removal, loss of recruitment, natural decay, and attrition. Some systems that are exceptions with generally good LWD abundance include the Ohanapecosh River, Clear Fork River, and Purcell Creek watersheds where 84%, 58%, and 59% respectively of the surveyed reaches of the river had good levels of LWD (USFS 1998a). Look for opportunities to enhance LWD, especially within the alluvial reaches of anadromous tributaries to the upper Cowlitz. TAG members considered the addition of instream LWD a priority within the subbasin.
- Development within the Cowlitz River floodplain and within the lower reaches of many tributaries has led to the active removal of LWD from diked and channelized areas. Educate landowners about the importance of retaining LWD in streams, and monitor and enforce regulations that prohibit this type of activity. Also look for opportunities to use alternative materials to replace existing bank stabilization projects.
- LWD recruitment potential is also generally low for most areas within the upper Cowlitz River subbasin. Replant riparian areas with conifers to provide a future supply of LWD, especially along the lower reaches of Kiona, Silver, Davis, Garrett, Burton, Willame, Smith, Hall, Skate, and Butter creeks.

Riparian Conditions

- Land use activities (farming, grazing, timber harvesting, and industrial and residential development) have removed most of the mature riparian vegetation on private lands along the upper Cowlitz River and along at least the lower gradient portions of most tributaries feeding the upper Cowlitz (Harza Patient 1997b; USFS 1997a; USFS 1997b; Meyer et. al. 2000: letter). Many of the low gradient reaches of tributaries that have experienced substantial riparian impacts are also important spawning and rearing areas for anadromous salmonids. Look for opportunities to increase riparian cover, especially coniferous cover, starting with some of the most productive tributaries; including Skate, Johnson, Silver, and Kiona Creeks.

Water Quality

- Two streams on the upper Cowlitz were listed on the 1996 and 1998 303d list for temperature exceedances above state standards, Silver Creek and Willame Creek. While Kiona, Peters, and Oliver creeks were not listed on the 303d list, elevated water temperatures and low Dissolved Oxygen (DO) concentrations were measured in 1992, 1993, and 1994. The USFS Middle Cowlitz Watershed Analysis (1997a) states that the excessive water temperatures likely relates to the poor riparian conditions within the watershed. Protect existing riparian vegetation and restore riparian cover where it has been removed. This includes smaller stream channels where cumulative effects on water temperature and quality can impact the entire anadromous zone.

- The combination of low flows and high width-to-depth ratios caused by excessive sediment inputs into many of the important tributary streams contributes to increases in water temperatures. Juvenile fish rearing within some of these systems may find themselves stranded in disconnected pools with elevated water temperatures. It will be important to address cumulative land use impacts that contribute sediment inputs and lead eventually to elevated water temperatures.

Water Quantity

- With the current operational requirements for Cowlitz Falls Dam, drawdowns occur as often as 6 to 8 times per year. This often results in the flushing of fish downstream where they are lost within Riffe Lake. Assess the impact to salmonids from the frequent drawdowns that are now required, and look for ways to operate the dam that will both protect property and reduce impacts to salmonids.
- Low-flow and subsurface flow problems also occur in many of the upper Cowlitz River tributaries. Some of the problems are associated with channel aggradation due to excessive sediment inputs and/or stream channel alterations, leading to a reduction in available habitat. Assess and look for ways to reduce low flow problems on Cowlitz River tributaries starting with some of the more productive streams including Kiona Creek and its tributaries, Davis Creek, and Willame Creek.
- Increased peak flows may also negatively impact a number of stream systems within the upper Cowlitz River subbasin. Hydrologic impacts from increased peak flows can be expected in watersheds with <60% of the watershed in forest stands aged 25 years or older (see Appendix B: Habitat Rating Standards). The most productive subbasins with a high potential for increased peak flows include Kiona, Silver, Willame, and Davis (USFS 1997a and 1997b). It will be important to reduce harvest levels within these subbasins until the vegetation covering a majority of the watersheds recovers.

Biological Processes

- Comparing the level of stocking that is occurring today with historical run sizes, it is likely that habitats in the upper Cowlitz River subbasin are not receiving adequate nutrients from the carcasses of spawned out fish to fully support the aquatic and riparian communities. Assess nutrient levels within the upper subbasin, and look for opportunities to supplement nutrient levels where appropriate.

HABITATS IN NEED OF PROTECTION

Recommendations:

The WRIA 26 Technical Advisory Group (TAG) had some difficulty narrowing down specific areas within the various basins that provide habitats in need of protection, mainly because almost the entire basin provides important habitat for some species during some life-history stage. Also, what occurs upstream of critical habitat areas has direct bearing on the quality of downstream habitat. However, there are general areas within each basin that provide especially important habitat for the various species. These areas are listed below by subbasin.

Coweeman Subbasin:

- The Coweeman River supports one of the few remaining runs of wild fall chinook in the lower Columbia basin. Fall chinook spawning and rearing occurs mainly within the mainstem from the mouth of Goble Creek (RM 11.4) to Baird Creek (RM 25.9).
- Most of the floodplain habitat within the Coweeman subbasin has been diked and disconnected from the river. Some of the only remaining connected floodplain habitat occurs between RM 4 and RM 7.5. While not all of this reach contains properly functioning habitat, it still contains undeveloped areas that would be considerably less expensive and less difficult to enhance and restore.
- The most productive tributaries to the Coweeman subbasin include Mulholland, Baird, and Goble creeks (in order of priority).
- Floodplain and wetland habitat along the lower Cowlitz mainstem (RM 20 to the mouth) has been mostly filled with dredge spoils from the eruption of Mount St. Helens and diked (see Map 10a). Development is rapidly occurring on these filled floodplains, precluding future restoration or enhancement activities. Considering the limited amount of floodplain habitat available within the lower Cowlitz, it would be important to identify potential restoration sites and work toward their protection. Historically, this area produced more fall chinook than any other area in the Cowlitz basin (Mobrand Biometrics 1999).

Lower Cowlitz Subbasin:

Harza (2000) identified a number of important side channel locations along the lower Cowlitz mainstem between RM 20 and RM 49 that need protection and enhancement (see Table 50). These areas provide some of the only functioning spawning and rearing habitat left in the lower Cowlitz mainstem, especially for fall chinook and steelhead.

- Monahan Creek provides important coho, steelhead, and fall chinook habitat and was characterized by the TAG as having the best habitat in the subbasin.
- The upper reaches of Olequa (above Winlock) and Delameter creeks provide important spawning and rearing habitat for steelhead, cutthroat, and coho.
- 1999 fish surveys identified chum in upper Lacamas Creek (TAG). There are very few areas that have been identified within the lower Columbia that still support

chum, and considering the depressed status of most stocks, this area may be important to protect and enhance.

Toutle River Subbasin

- The South Fork Toutle River has generally recovered quickly from the effects of the eruption of Mount St. Helens. TAG members felt that the South Fork contained the most important habitat within the Toutle subbasin. They also felt that the entire anadromous zone in the mainstem South Fork was important, along with the low-gradient reaches of its tributaries.
- The Green River is also recovering from the effects of the eruption and is now providing productive habitat for anadromous species. The most productive steelhead tributaries to the Green River include Elk and Devils creeks.
- Hoffstadt and Alder Creeks provide the most productive steelhead habitat within the North Fork Toutle watershed.
- Wyant Creek is a low-gradient coho stream that has some "nice" habitat in the upper reaches, but still has some significant problems within the lower reaches.

Mayfield/Tilton Subbasin:

- Side- and off-channel habitat is generally limited within the Tilton watershed, and juveniles have minimal refuge from high flows that often flush them out of the river. Side-channel habitat below the town of Morton provides some critical areas with refuge from high flows.
- Winston Creek supports a "healthy" run of resident cutthroat trout that need protection.
- TAG members noted that some of the best habitat within the Tilton watershed occurs within the South Fork Tilton, the mainstem Tilton from Nineteen Creek (RM 22.9) to the falls (RM 25), and in the West Fork Tilton.
- Coon, Snow, and Trout creeks, tributaries to the North Fork, have coarse, unembedded substrates with pocket water and complex, shallow, channel margins that are ideal as summer-rearing areas for steelhead and resident trout (Murray Pacific 1998).
- The lower West Fork Tilton contains "especially productive coho habitat," and good summer and winter habitat is available for all salmonid species and lifestages (Murray Pacific 1998).

Riffe Lake Subbasin:

In general, protection of anadromous habitat within the Riffe Lake subbasin is not a high priority because of the existing passage problems through the Lake and through Mossyrock Dam for downstream migrants. However, if resident and adfluvial forms of coastal cutthroat trout are listed under the ESA, identification of critical habitat would become a much higher priority. Little information is presently available on the distribution and condition of resident, fluvial, and adfluvial cutthroat populations.

Additional surveys would be needed to identify priority habitat for the various forms of cutthroat trout within the subbasin.

Cispus Subbasin:

- In general, the North Fork Cispus provides some of the best functional habitat in the subbasin and protection of this system is the highest priority in the subbasin.
- Off-channel rearing habitat is limited within the Cispus subbasin. The mainstem Cispus between Iron Creek (RM 8.2) and the North Fork Cispus (RM 19.9) has good side-channel and off-channel habitat that provides important rearing and overwintering habitat for juveniles within the subbasin. It will be important to protect the area immediate area as well as upstream habitat.
- Yellowjacket Creek provides a substantial amount of the tributary habitat within the Cispus subbasin and should be restored and protected.
- Enhance the fair-quality habitats in the North Fork Cispus, Yellowjacket Creek, and Greenhorn Creek, (in order of priority).
- Maintain the high-quality habitats in Woods, Orr, and Iron creeks.

Upper Cowlitz Subbasin:

- The lower reaches of the Ohanapecosh, Clear Fork, and Muddy Fork have some of the most pristine spawning and rearing habitat remaining within this subbasin. The lower reaches of the Ohanapecosh, and Clear Fork provide especially critical spring chinook spawning habitat.
- Only short reaches of low-gradient tributary habitat are available in the upper Cowlitz River subbasin. These areas, along with the mainstem Cowlitz provide especially critical spawning and rearing habitat for all species within the upper subbasin.
- Of the major tributaries, Skate Creek has probably the best available habitat, as well as, the most extensive use by anadromous species.
- Johnson Creek and Silver Creek are also productive tributary streams and are important areas in which to focus habitat protection.

DATA GAPS

The ability to determine what factors are limiting salmonid production, and to prioritize those factors within and between drainages, is limited by the current lack of specific habitat assessment data. Some Forest Service lands, commercial forestry property, areas affected by the operation of the dams, and some stream systems that have been surveyed by Conservation Districts have had systematic physical habitat assessments that help quantify habitat condition and fish usage. However, a general lack of data for many areas was especially apparent when the TAG began discussions on the smaller tributaries. Collecting this baseline data will be critical for developing effective recovery and restoration plans, for prioritizing future recovery efforts, and for monitoring the success of those efforts. The following list identifies specific areas where the collection of additional data could improve understanding of WRIA 26 habitat limiting factors.

Watershed Condition:

Understanding how various processes are operating at the basin level would substantially benefit the analysis of habitat limiting factors. With an understanding and quantification of the hydrology, sediment input and transport, nutrient cycling, and vegetation structure of the basin, it becomes possible to better understand the relationships and develop connections between specific land uses and subsequent changes in aquatic ecosystems. For example, at what level of impervious surface, road density and/or of timber harvest within a basin do peak flows increase to levels that significantly alter stream channel morphology and sediment transport? Without this watershed-scale picture, we often attempt to treat the symptoms without understanding the disease, and our restoration efforts fail. Studies that would benefit the understanding of conditions within every major basin within WRIA 26 include:

- GIS analysis, with groundtruthing, of the vegetation structure and composition of each basin using recent satellite photos;
- A peak flow analysis examining hydrologic maturity, road networks, and percent of impervious surfaces within the subbasins of WRIA 26;
- A sediment budget that describes input and transport within each subbasin;
- An analysis of riparian conditions and the potential for LWD recruitment within each subbasin.

Also, an important data gap within most subbasins is the historical condition of habitat and fish stocks. Some information on historical floodplain conditions, plant communities, and hydrology can be gleaned from historical land-use documents. This historical background data can add significantly to our understanding of limiting factors within the basin.

Distribution and Condition of Stocks

Information was generally lacking on the distribution and recent condition of most stocks within WRIA 26. Data on the condition of salmon stocks in Columbia River was last compiled and analyzed as part of the SASSI report in 1992, and steelhead stock condition was last published as part of the Lower Columbia Steelhead Conservation Initiative (LCSCI) in 1997. Updated information on the status of wild stocks will be critical for both focusing restoration efforts and monitoring the success of the restoration efforts. It will be important to monitor stock status by maintaining, or if possible, expanding ongoing trapping efforts and carcass and redd surveys.

It will also be important to increase the scope of existing spawning ground and stream surveys within WRIA 26. These surveys only cover a limited amount of habitat within each basin. There is minimal data on fish distribution available for areas like the smaller tributaries and floodplain habitats. Conducting additional fish surveys on smaller tributaries and in areas outside of standard index reaches would provide a much better picture of how various life-history stages for each species are utilizing habitat within the WRIA and will help identify where habitat may be limited.

Fish surveys also do not often include the mainstem of many of the larger rivers within WRIA 26. TAG members noted that very little is known of habitat conditions and fish use for the mainstems of larger systems.

Data on the occurrence, abundance, and hybridization of bull trout with brook trout is lacking in areas of the upper Cowlitz watershed. Data on the occurrence and abundance of cutthroat trout is also generally lacking throughout WRIA 26.

Straying of hatchery fish may be a significant problem within the lower Cowlitz River Subbasin (TAG). TAG members suggested that Monahan Creek may be an appropriate stream to place a fish trap to both measure straying rates and potential impacts and to exclude hatchery fish from the upper watershed.

Access

The dams on the Cowlitz River represent the major access problem within WRIA 26, and it will be critical to the success of reintroduction efforts that the Cowlitz Falls Fish Collection Facility continues to gather data on the efficiency of its operation.

There are problems with fish passage in the Toutle subbasin through Outlet Creek, through Silver Lake Dam, and then through Silver Lake into Hemlock Creek and other tributaries. The extent and severity of these fish passage problems need assessment.

Studies are also underway in the Mayfield/Tilton subbasin to determine where juvenile mortality is occurring within the subbasin, and the level of mortality. They are seeding the watershed with fry and then tagging smolts as they move through Mayfield Dam.

These studies will help focus efforts to establish sustainable runs of anadromous salmonids within this subbasin.

There are a number of culvert surveys and inventories underway that will provide additional information in the near future on fish passage issues within WRIA 26. In many instances, culvert repair and replacement are the simplest and most direct action that project sponsors can take to increase salmon habitat. However, these repairs are often expensive, and some repairs may really provide only insignificant benefits to salmon. A complete culvert inventory for WRIA 26 would provide the information that is needed to prioritize removal and repair of the most critical passage blockages. The data should be collected using consistent methodologies and should include an assessment of habitat conditions and fish use both upstream and downstream.

A culvert on Turner Creek, in the Coweeman Subbasin, has been identified as an important barrier to remove; yet, data is lacking on fish use within the creek. Fish surveys are needed to establish the relative importance of removing the barrier.

A culvert and dam on lower Ferrier Creek are reported to be passage barriers (TAG). A further assessment of fish habitat and presence is needed, as well as an assessment of possible corrective measures.

Floodplain Connectivity:

Very little floodplain habitat remains within the lower Cowlitz River basin. Specific habitat surveys have not been conducted that could help identify potential floodplain enhancement sites. Development is rapidly occurring on dredge spoils and other areas within the historic floodplain of the Cowlitz, and restoration or enhancement possibilities are rapidly disappearing. Without additional information on the restoration and enhancement potential for these sites, critical rearing habitat will be lost.

Floodplain rearing habitat is also limited in the Tilton/Mayfield, Upper Cowlitz, and Cispus subbasins. Assessment of the extent of available floodplain habitat and identification of potential enhancement sites could help establish restoration priorities within this subbasin.

Streambed Sediment Conditions:

There was a general lack of information on streambed sediment conditions for most of the tributaries in WRIA 26. Other than a few areas on federal lands and specific stream systems with surveys, data was either completely lacking on sediment conditions or we had a qualitative estimate by TAG members familiar with the stream system.

There are a few general areas where physical surveys of sediment conditions would be especially important including:

- Channel aggradation from sediment inputs in the lower reaches of a number of productive tributaries in the upper Cowlitz subbasin including, Kiona, Oliver, Peters, Hampton, Silver, Siler, Davis, Smith, Johnson, lower Lake, lower Butter, Skate, and Willame Creek.
- WDW (1990) noted that sedimentation and gravel quality are habitat constraints on the production of coastal cutthroat, winter steelhead, fall chinook, and coho within the Coweeman subbasin. Sedimentation is likely a major limiting factor within the subbasin, and an assessment is needed to determine the geographic scope and severity of the problem.
- The TAG noted that spawning substrates are deficient within the North and East Forks of the Tilton. Assessments are needed to determine the extent of this problem and to identify reasons for the deficit.
- Access is now limited to most of the South side of the upper South Fork Toutle River due to the eruption of Mount St. Helens. Roads within this area need assessment and repair to reduce potential inputs of fine sediments to downstream habitats.
- Several subbasins have numerous stream-adjacent roads that need assessment, as they may be contributing excessive fine sediments to spawning substrates in the WRIA. The highest priority subbasins to assess should include the Coweeman, Toutle, and Mayfield/Tilton.
- Spawning gravel augmentation has been proposed for the mainstem Cowlitz below the Barrier Dam. It will be important to gather data on fish usage before gravel augmentation and to continue to monitor gravel availability and use after the project begins.
- Embedded spawning sediments and sediment mobility continue to be major problems within the North Fork and mainstem Toutle Rivers. Assessment is needed to determine the extent of the problems associated with chronic fine-sediment inputs from the Sediment Retention Structure, and to look for alternatives that might reduce or eliminate the problems.
- There is just a general lack of data on specific substrate conditions within most stream systems. Comprehensive and consistent stream surveys are needed throughout the WRIA to help prioritize restoration activities.

Channel Conditions:

Specific data on channel conditions within many of the streams within WRIA 26 was also generally lacking. Watershed Analyses from the Forest Service and timber companies again provided the most comprehensive data for channel conditions within the WRIA, except that this data is only available for certain areas. Even when data is available on channel conditions, the types of data collected, methodologies for collecting the data, the scale at which the data is collected, and the types of assessment used are often different and conversion is generally difficult. A comprehensive stream survey using similar methodologies collected at similar scales would provide the type of consistent data needed to develop restoration and recovery plans with a set of specific actions and priorities.

Specific areas that need additional study include:

- Data on channel conditions within Olequa, Lacamas, and Salmon creeks in the lower Cowlitz subbasin, and Ostrander and Salmon creeks in the Coweeman subbasin is generally lacking.
- Access is limited to the south side of the upper South Fork Toutle River, and subsequently information on channel and habitat conditions within the area is limited.
- Data on channel conditions within the mainstems of the upper Cowlitz, the Cispus, North Fork and mainstem Toutle, and the Tilton River is generally lacking.
- Data on side-channel and off-channel availability within mainstem of the upper Cowlitz and in the lower end of its tributaries is lacking. Substantial amounts of these types of rearing and spawning habitats have been lost in the upper subbasin due to inundation from Lake Scanewa and channel modifications, and the loss may be severely limiting production of salmonids within the upper basin.
- There is little information on the current condition of side channels in the Tilton River watershed, and there are few comparisons to historical conditions. Overflow channels exist on the mainstem Tilton River (TAG), but it is not known how many there are or the quality of the habitat that they provide. Considering that excessive flows were noted as a significant problem for juveniles attempting to rear in the Tilton watershed, off- and side-channel habitat might be especially crucial habitat. Assessment is needed of the rearing habitat and conditions within the Tilton watershed.
- Assessment is needed regarding the serious bank instability problems that are ongoing in the East and North Forks of the Tilton.

Riparian Conditions

Riparian conditions are generally considered poor throughout WRIA 26 (Table 4); however, that assessment used very coarse-scale land cover data dating back to 1993. This data needs to be updated using more recent satellite photos for vegetation cover, and additional groundtruthing should be incorporated. Where possible, formal riparian inventories should be conducted that include data on growth, age, species, and disturbance mechanisms for riparian vegetation.

Water Quality:

Water quality data within WRIA 26 is spotty, with very little information available for most of the tributaries to the main rivers. Without comprehensive coverage of all systems within the WRIA, it is difficult to pull together a picture of what types of problems are occurring and where. Water quality problems are generally no longer associated with point sources of pollution, but are now more a matter of cumulative impacts from a number of land uses across the landscape. Identifying the relationships between specific land uses and associated water quality problems and then finding solutions to these problems, requires an extensive and ongoing monitoring program.

Elevated stream temperatures are consistent problems on many systems within WRIA 26, especially within many of the lower elevation watersheds where land-use impacts and hydrologic modifications have been extensive. While this report identifies a number of areas where water temperatures may be limiting salmonid production, there may also be other area within the WRIA with significant problems that haven't as yet been identified because there is insufficient water quality monitoring. Additional water quality monitoring would help to identify areas where stream temperatures are elevated and to identify potential land uses that contribute to the problems. This may be the only way to begin to address water quality issues at both the site specific and watershed level.

One major problem with the existing water quality monitoring programs is that water quality standards are not necessarily based on the needs of fish, and restoration strategies based on these standards may not adequately protect fish. It will be important to update water quality standards to assure protection of threatened and endangered fish species.

Specific areas that need additional study include:

- Water quality studies are needed within the Lacamas Creek watershed in the lower Cowlitz subbasin to identify the problems areas and the sources.
- Water quality assessments of the Coweeman River basin.
- Water temperature data in general for the upper Cowlitz River and the lower reaches of its tributaries.
- Turbidity problems in the North Fork Toutle and mainstem Toutle related to the Sediment Retention Structure need continuing assessment.
- Water quality issues related to fish farming in the Tilton River watershed.

Water Quantity:

The Department of Ecology, in cooperation with the Department of Fish and Wildlife, conducted an instream flow study on the Coweeman River, and Ostrander, Leckler, Olequa, Lacamas, Salmon, Cedar, Mill, and Winston Creeks. While the study identified the optimum flow for both spawning and rearing for various species, it did not identify flows necessary for incubation of fish eggs, smolt out-migration, fish passage to spawning grounds, and prevention of stranding fry and juveniles. Meeting these needs is required when setting minimum instream flows. Nor did the study consider other variables that might also be impacted by low flows such as water temperature, water quality, and sediment load.

The data from Ecology's study shows that low-flow may be limiting rearing habitat for salmonid juveniles during the summer and fall months. These are also the times when elevated water temperatures stress juveniles rearing in already limited habitat. The combination of these factors needs additional research to determine the impacts to fish that must find suitable rearing habitat within fresh water year-round. It will be important to incorporate this additional information into the models before determining appropriate minimum instream flows.

Many of the stream gages that could provide critical information on stream flows are no longer in use. The TAG suggested restoring and monitoring as many of these gages as possible.

With the current operational requirements for Cowlitz Falls Dam, drawdowns occur as often as 6 to 8 times per year. This often results in the flushing of fish downstream where they are lost within Riffe Lake. Assess the impact to salmonids from the frequent drawdowns that are now required, and look for ways to operate the dam that will both protect property and reduce impacts to salmonids.

Biological Processes:

Escapement for most anadromous salmonids is well below historic levels, and aquatic ecosystems are likely negatively affected by the loss of nutrients. Assessment of nutrient levels within the various subbasins is needed to quantify the extent of the impacts.

There are a number of areas where hydrological modifications combined with introduced species may be increasing predation, disease, and competition for resources. The extent of these impacts is generally unknown, and assessment of the potential impacts to salmonids from these activities will be especially important within the Silver Lake watershed, and within the Mayfield/Tilton subbasin.

A private salmon farmer is raising Atlantic salmon on Cinnabar Creek and has permits to start a farming operation on the Tilton River. Assessment of the potential impacts to threatened native salmonids is critical to reintroduction efforts in the Mayfield/Tilton subbasin.

Habitats in Need of Protection

Identification of important habitats that need protection was based on the collective knowledge of the TAG members. While the fisheries and habitat experts on a stream system are likely to identify the most critical habitats, it would be important to develop a standardized methodology for identifying these areas that could then be applied consistently across the region.

Additional data on the distribution and abundance of the various species during all life-history stages and on existing habitat conditions would also benefit the analysis of which habitats are truly the most critical to protect within each basin.

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APPENDICES

Appendix A: Maps

Several maps have been included with this report for your reference. The maps are appended to the report as a separate electronic file. The maps are included as a separate electronic file to enable the reader to utilize computer multi-tasking capabilities to simultaneously bring up the map and associated text. For printed hard copies of the report add the 11 by 17 inch maps to this appendix. Below is a list of maps that are included in the WRIA 26 map appendix/file:

Appendix B: Salmonid Habitat Condition Rating Standards for Identifying Limiting Factors

Under the Salmon Recovery Act (passed by the legislature as House Bill 2496, and later revised by Senate Bill 5595), the Washington Conservation Commission (WCC) is charged with identifying the habitat factors limiting the production of salmonids throughout most of the state. This information should guide lead entity groups and the Salmon Recovery Funding Board in prioritizing salmonid habitat restoration and protection projects seeking state and federal funds. Identifying habitat limiting factors requires a set of standards that can be used to compare the significance of different factors and consistently evaluate habitat conditions in each WRIA throughout the state.

In order to develop a set of standards to rate salmonid habitat conditions, several tribal, state, and federal documents that use some type of habitat rating system were reviewed (see Table 51). The goal was to identify appropriate rating standards for as many types of habitat limiting factors as possible, with an emphasis on those that could be applied to readily available data. Based on the review, it was decided to rate habitat conditions into three categories: Good, Fair, and Poor. For habitat factors that had wide agreement on how to rate habitat condition, the accepted standard was adopted by the WCC. For factors that had a range of standards, one or more of them were adopted. Where no standard could be found, a default rating standard was developed, with the expectation that it will be modified or replaced as better data become available.

The ratings adopted by the WCC are presented in Table 52. These ratings are not intended to be used as thresholds for regulatory purposes, but as a coarse screen to identify the most significant habitat limiting factors in a WRIA. They also will hopefully provide a level a consistency between WRIAs that allows habitat conditions to be compared across the state. However, for many habitat factors, there may not be sufficient data available to use a rating standard or there may be data on habitat parameters where no rating standard is provided. For these factors, the professional judgment of the TAG should be used to assign the appropriate ratings. A set of narrative standards will be developed in the near future to provide guidance in this situation.

In some cases there may be local conditions that warrant deviation from the rating standards presented here. This is acceptable as long as the justification and a description of the procedures that were followed are clearly documented in the limiting factors report. Habitat condition ratings specific to streams draining east of the Cascade crest were included where they could be found, but for many parameters they were not. Additional rating standards will be included as they become available. In the meantime, TAGs in these areas will need to work with the standards presented here or develop alternatives based on local conditions. Again, if deviating from these standards, the procedures followed should be clearly documented in the limiting factors report.

Table 51. Source documents

Code	Document	Organization
Hood Canal	Hood Canal/Eastern Strait of Juan de Fuca Summer Chum Habitat Recovery Plan, Final Draft (1999)	Point No Point Treaty Council, Skokomish Tribe, Port Gamble S'Klallam Tribe, Jamestown S'Klallam Tribe, and Washington Department of Fish and Wildlife
ManTech	An Ecosystem Approach to Salmonid Conservation, vol. 1 (1995)	ManTech Environmental Research Services for the National Marine Fisheries Service, the US Environmental Protection Agency, and the US Fish and Wildlife Service
NMFS	Coastal Salmon Conservation: Working Guidance for Comprehensive Salmon Restoration Initiatives on the Pacific Coast (1996)	National Marine Fisheries Service
PHS	Priority Habitat Management Recommendations: Riparian (1995)	Washington Department of Fish and Wildlife
Skagit	Skagit Watershed Council Habitat Protection and Restoration Strategy (1998)	Skagit Watershed Council
WSA	Watershed Analysis Manual, v4.0 (1997)	Washington Forest Practices Board
WSP	Wild Salmonid Policy (1997)	Washington Department of Fish and Wildlife

Table 52. WCC salmonid habitat condition ratings

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Access and Passage						
Artificial Barriers	% known/potential habitat blocked by artificial barriers	All	>20%	10-20%	<10%	WCC
Floodplains						
Floodplain Connectivity	Stream and off-channel habitat length with lost floodplain connectivity due to incision, roads, dikes, flood protection, or other	<1% gradient	>50%	10-50%	<10%	WCC
Loss of Floodplain Habitat	Lost wetted area	<1% gradient	>66%	33-66%	<33%	WCC
Channel Conditions						
Fine Sediment	Fines < 0.85 mm in spawning gravel	All – Westside	>17%	11-17%	≤11%	WSP/WSA / NMFS/Hood Canal

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
	Fines < 0.85 mm in spawning gravel	All – Eastside	>20%	11-20%	≤11%	NMFS
Large Woody Debris	pieces/m channel length	≤4% gradient, <15 m wide (Westside only)	<0.2	0.2-0.4	>0.4	Hood Canal/Skagit
	or use Watershed Analysis piece and key piece standards listed below when data are available					
	pieces/channel width	<20 m wide	<1	1-2	2-4	WSP/WSA
	key pieces/channel width*	<10 m wide (Westside only)	<0.15	0.15-0.30	>0.30	WSP/WSA
	key pieces/channel width*	10-20 m wide (Westside only)	<0.20	0.20-0.50	>0.50	WSP/WSA
	* Minumim size to qualify as a key piece:		BFW (m) 0-5 6-10 11-15 16-20	Diameter (m) 0.4 0.55 0.65 0.7	Length (m) 8 10 18 24	
Percent Pool	% pool, by surface area	<2% gradient, <15 m wide	<40%	40-55%	>55%	WSP/WSA
	% pool, by surface area	2-5% gradient, <15 m wide	<30%	30-40%	>40%	WSP/WSA

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
	% pool, by surface area	>5% gradient, <15 m wide	<20%	20-30%	>30%	WSP/WSA
	% pool, by surface area	>15 m	<35%	35-50%	>50%	Hood Canal
Pool Frequency	channel widths per pool	<15 m	>4	2-4	<2	WSP/WSA
	channel widths per pool	>15 m	-	-	chann width / pools/ mile / cw/ pool 50' 26 4.1 75' 23 3.1 100' 18 2.9	NMFS
Pool Quality	pools >1 m deep with good cover and cool water	All	No deep pools and inadequate cover or temperature, major reduction of pool volume by sediment	Few deep pools or inadequate cover or temperature, moderate reduction of pool volume by sediment	Sufficient deep pools	NMFS/WSP/WSA
Streambank Stability	% of banks not actively eroding	All	<80% stable	80-90% stable	>90% stable	NMFS/WSP
Sediment Input						
Sediment Supply	$m^3/km^2/yr$	All	> 100 or exceeds natural rate*	-	< 100 or does not exceed natural rate*	Skagit
	* Note: this rate is highly variable in natural conditions					

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Mass Wasting		All	Significant increase over natural levels for mass wasting events that deliver to stream	-	No increase over natural levels for mass wasting events that deliver to stream	WSA
Road Density	mi/mi^2	All	>3 with many valley bottom roads	2-3 with some valley bottom roads	<2 with no valley bottom roads	NMFS
	Or use results from Watershed Analysis where available					
Riparian Zones						
Riparian Condition	• riparian buffer width (measured out horizontally from the channel migration zone on each side of the stream) • riparian composition	Type 1-3 and untyped salmonid streams >5' wide	<75' or <50% of site potential tree height (whichever is greater) OR Dominated by hardwoods, shrubs, or non-native species (<30% conifer) unless these species were dominant historically.	75'-150' or 50-100% of site potential tree height (whichever is greater) AND Dominated by conifers or a mix of conifers and hardwoods (≥30% conifer) of any age unless hardwoods were dominant historically.	• >150' or site potential tree height (whichever is greater) AND • Dominated by mature conifers (≥70% conifer) unless hardwoods were dominant historically	WCC/WSP
	• buffer width • riparian composition	Type 4 and untyped perennial streams <5' wide	<50' with same composition as above	50'-100' with same composition as above	>100' with same composition as above	WCC/WSP

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
	• buffer width • riparian composition	Type 5 and all other untyped streams	<25' with same composition as above	25'-50' with same composition as above	>50' with same composition as above	WCC/WSP
Water Quality						
Temperature	degrees Celsius	All	>15.6° C (spawning) >17.8° C (migration and rearing)	14-15.6° C (spawning) 14-17.8° C (migration and rearing)	10-14° C	NMFS
Dissolved Oxygen	mg/L	All	<6	6-8	>8	ManTech
Hydrology						
Flow	hydrologic maturity	All	<60% of watershed with forest stands aged 25 years or more	-	>60% of watershed with forest stands aged 25 years or more	WSP/Hood Canal
		or use results from Watershed Analysis where available				
	% impervious surface	Lowland basins	>10%	3-10%	≤3%	Skagit
Biological Processes						
Nutrients (Carcasses)	Number of stocks meeting escapement goals	All Anadromous	Most stocks do not reach escapement goals each year	Approximately half the stocks reach escapement goals each year	Most stocks reach escapement goals each year	***WCC***

Appendix C: Fish Distribution Definitions

The following definitions were used to develop fish distribution maps for WRIA 26:

Known:

Habitat that is documented to presently sustain fish populations (published sources, survey notes, first-hand sightings, etc.): or, habitat with records of fish use (which may or may not be known to have been extirpated for some reason). This includes habitat used by all life history stages for any length of time (i.e. intermittent streams which contain water during flood flows that provides refuge habitat for a period of hours or days).

Presumed:

Habitat with no records of known fish use, but that is below any known natural barrier (including sustained 12% gradient) and otherwise conforms to species-specific habitat criteria.

Potential:

Habitat above human-caused blockages or obstructions that could be opened to fish use and that is below any known natural barrier (including sustained 12% gradient) and otherwise conforms to species-specific habitat criteria.

Artificial:

Includes habitat with Known presence of salmonids that are supported by an active fish passage operation (such as a trap and haul facility) or a structure providing passage around a dam or natural passage barrier. Known habitat occupied exclusively by hatchery outplants or strays may also be included.

Appendix D: Glossary

303 (d) List: The federal Clean Water Act requires states to maintain a list of stream segments that do not meet water quality standards. The list is called the 303(d) list because of the section of the Clean Water Act that makes the requirement.

Adaptive management: Monitoring or assessing the progress toward meeting objectives and incorporating what is learned into future management plans.

Adfluvial: Migratory between lakes and rivers or streams or, life history strategy in which adult fish spawn and juveniles subsequently rear in streams but migrate to lakes for feeding as subadults and adults. Compare fluvial.

Administratively Withdrawn Areas: A land management designation for federally-administered lands within the range of the northern spotted owl (USFS and BLM 1994). Administratively Withdrawn Areas are identified in current Forest and District Plans or draft plan preferred alternatives and include recreation and visual areas, back county, and other areas where management emphasis precludes scheduled timber harvest.

Aggradation: The geologic process of filling and raising the level of the streambed or floodplain by deposition of material eroded and transported from other areas.

Alluvial: Deposited by running water.

Alluvial fan: A relatively flat to gently sloping landform composed of predominantly coarse grained soils, shaped like an open fan or a segment of a cone, deposited by a stream where it flows from a mountain valley onto a plain or broader valley, or wherever the stream gradient suddenly decreases. Alluvial fans typically contain several to many distributary channels that migrate back and forth across the fan over time. This distribution of flow across several stream channels provide for less erosive water velocities, maintaining and creating suitable rearing salmonid habitat over a wide range in flows.

Anadromous fish: Species that are hatched in freshwater mature in saltwater, and return to freshwater to spawn.

Anchor ice: Forms along the channel bottom form the accumulation of frazil ice particles on the rough surfaces of coarse bottom sediments and on the lee sides of pebble, cobbles, and boulders.

Aquifer:

1. A subsurface layer of rock permeable by water. Although gravel, sand sandstone and limestone are the best conveyors of water, the bulk of the earth’s rock is composed of clay, shale and crystalline.

2. A saturated permeable material (often sand, gravel, sandstone or limestone) that contains or carries groundwater.

3. An underground, water-bearing layer of earth, porous rock, sand, or gravel, through which water can seep or be held in natural storage. Aquifers generally hold sufficient water to be used as a water supply.

Basin: The area of land that drains water, sediment and dissolved materials to a common point along a stream channel.

Basin flow: Portion of stream discharge derived from such natural storage sources as groundwater, large lakes, and swamps but does not include direct runoff or flow from stream regulation, water diversion, or other human activities.

Bioengineering: Combining structural, biological, and ecological concepts to construct living structures for erosion, sediment, or flood control.

Biological Diversity (biodiversity): Variety and variability among living organisms and the ecological complexes in which they occur; encompasses different ecosystems, species, and genes.

Biotic Integrity: Capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region; a system's ability to generate and maintain adaptive biotic elements through natural evolutionary processes.

Biological oxygen demand: An indirect measure of the concentration of biologically degradable material present in organic wastes. It usually reflects the amount of oxygen consumed in five days by biological processes breaking down organic waste.

Braided stream: Stream that forms an interlacing network of branching and recombining channels separated by branch islands or channel bars.

Buffer: An area of intact vegetation maintained between human activities and a particular natural feature, such as a stream. The buffer reduces potential negative impacts by providing an area around the feature that is unaffected by this activity.

Capacity: the amount of available habitat for a specific species or lifestage within a given area. Capacity is a density-dependent measure of habitat quantity.

Carrying capacity: Maximum average number or biomass of organisms that can be sustained in a habitat over the long term. Usually refers to a particular species, but can be applied to more than one.

Channelization: Straightening the meanders of a river; often accompanied by placing riprap or concrete along banks to stabilize the system.

Channelized stream: A stream that has been straightened, runs through pipes or revetments, or is otherwise artificially altered from its natural, meandering course.

Channel Migration Zone: lateral movement of channel leads to a sequence of events through time where terraces are formed and new floodplain areas are defined.

Channel Stability: Measure of the resistance of a stream to erosion that determines how well a stream will adjust and recover from changes in flow or sediment transport.

Check dams: Series of small dams placed in gullies or small streams in an effort to control erosion. Commonly built during the 1900s.

Confinement: When a channel is fixed in a specific location restricting its pattern of channel erosion and migration

Confluence: the flowing together of two or more streams, or the combined stream formed by the conjunction.

Congressionally Reserved Areas: A land management designation for federally-administered lands within the range of the northern spotted owl (USFS and BLM 1994). These areas include Wildernesses, Wild and Scenic Rivers, National Monuments, as well as other federal lands not administered by the Forest Service or BLM.

Connectivity: Unbroken linkages in a landscape, typified by streams and riparian areas.

Constriction: The narrowing of a channel that impedes the downstream movement of water or debris

Critical Stock: A stock of fish experiencing production levels that are so low that permanent damage to the stock is likely or has already occurred.

Depressed Stock: A stock of fish whose production is below expected levels based on available habitat and natural variations in survival levels, but above the level where permanent damage to the stock is likely.

Debris torrent: A type of landslide characterized by water-charged, predominantly coarse grained soil and rock fragments, and sometimes large organic material, flowing rapidly down a pre-existing channel.

Degradation: The lowering of the streambed or widening of the stream channel by erosion. The breakdown and removal of soil, rock and organic debris.

Deposition: The settlement of material out of the water column and onto the streambed.

Distributaries: A river branch flowing away from the main stream.

Diversity: Variation that occurs in plant and animal taxa (i.e., species composition), habitats, or ecosystems. See *species richness.*

Ecological restoration: Involves replacing lost or damaged biological elements (populations, species) and reestablishing ecological processes (dispersal, succession) at historical rates.

Ecosystem: Biological community together with the chemical and physical environment with which it interacts.

Ecosystem management: Management that integrates ecological relationships with sociopolitical values toward the general goal of protecting or returning ecosystem integrity over the long term.

Endangered Species Act: A 1973 Act of Congress that mandated the protection and restoration of endangered and threatened species of fish, wildlife and plants.

Endangered Species: Any species which is in danger of extinction throughout all, or a significant portion of its range, other than a species of the Class Insecta, as determined by the Secretary to constitute a pest.

Escapement: Those fish that have survived all fisheries and will make up a spawning population.

Estuarine: Of, or relating to, or formed in an estuary.

Estuary: A partly enclosed coastal body of water that has free connection to open sea, and within which seawater is measurably diluted by fresh river water.

Eutrophic: Pertaining to a lake or other body of water rich in dissolved nutrients, photosynthetically productive, and often deficient in oxygen during warm periods. Compare *oligotrophic.*

Evolutionary Significant Unit (ESU): A definition of a species used by National Marine Fisheries Service (NMFS) in administering the Endangered Species Act. An ESU is a population (or group of populations) that is reproductively isolated from other conspecific population units, and (2) represents an important component in the evolutionary legacy of the species.

Extirpation: The elimination of a species from a particular local area.

Flood: A rising and overflowing of a body of water especially onto normally dry land.

Floodplain: The low-lying, topographically flat area adjacent to a stream channel which is regularly flooded by stream water on a periodic basis and which shows evidence of the action of flowing water, such as active or inactive flood channels, recent fluvial soils, rafted debris or tree scarring. It varies in width depending on size of river, relative rates of downcutting and resistance of the bedrock in the valley walls.

Flow regime: Characteristics of stream discharge over time. Natural flow regime is the regime that occurred historically.

Fluvial: Of or pertaining to, or living in streams or rivers; also, organisms that migrate between main rivers and tributaries. Compare *adfluvial*.

Frazil ice: Thin particles of ice suspended in the water. Produced where extensive channel ice is formed and the freezing supercools the stream water producing nuclei of "frazil ice" particles.

Gabion: Wire basket filled with stones, used to stabilize streambanks, control erosion, and divert stream flow.

Genetic Diversity Unit (GDU) is defined as: A group of genetically similar stocks that is genetically distinct from other such groups. The stocks typically exhibit similar life histories and occupy ecologically, geographically and geologically similar habitats. A GDU may consist of a single stock

Geomorphology: Study of the form and origins of surface features of the Earth.

Glides: Stream habitat having a slow, relatively shallow run of water with little or no surface turbulence.

Healthy Stock: A stock of fish experiencing production levels consistent with its available habitat and within the natural variations in survival for the stock.

Hydrologic Unit Code (HUC): classification system used to describe the sub-division of hydrologic units. The codes represent the four levels of classification in the hyrdrologic unit system. The first level divides the US into 21 major geographic areas, or regions, based on surface topography, containing the drainage area of a major river or series of rivers. The second level divides the 21 regions into 222 sub-regions, which includes the area drained by a river system, a reach of a river and its tributaries in that reach, a closed basin or, a group of streams forming a coastal drainage area. The third level subdivides many of the subregions into accounting units. These 352 units nest within, or are equivalent to, the sub-regions. The fourth level is the cataloging unit, a geographic area representing part or all of a surface drainage basin, a combination of basins, or a distinct hydrologic feature. These units subdivide the sub-regions and accounting units into approximately 2150 smaller areas.

Hydrograph: A graphic representation or plot of changes in the flow of water or in the elevation of water levels plotted against time.

Hydrology: Study of the properties, distribution, and effects of water on the Earth's surface, subsurface, and atmosphere.

Interagency Aquatic Database and GIS: contains Stream Inventory information from the USFS, Oregon Department of Fish and Wildlife, and the Bureau of Land Management and can be sorted by stream width and stream gradient.

Intermittent stream: Stream that has interrupted flow or does not flow continuously. Compare *perennial stream*.

Interstitial: Between the grains (or cells or other solid objects). Having to do with the small, narrow spaces (interstices) found in between grains of sand, large cells or atoms or molecules, different tissues in the body, or within soil. The pores between minerals in a rock or the areas in a crystal which are not lattice sites.

Intraspecific interactions: Interactions within a species.

Large Woody Debris (LWD): Any large piece of relatively stable woody material having a diameter greater than 10 cm and a length greater than 3 meters. LWD is an important part of the structural diversity of streams. The nature and abundance of LWD in a stream channel reflects past and present recruitment rates. This is largely determined by the age and composition of past and present adjacent riparian stands. Synonyms include: Large Organic Debris (LOD) and Coarse Woody Debris (CWD). Specific types of large woody debris include:

Affixed logs: Singe logs or groups of logs that are firmly embedded, lodged, or rooted in a stream channel.

Deadheads: Logs that are not embedded, lodged or rooted in the stream channel but are submerged and close to the surface.

Digger log: Log anchored to the stream banks and/or channel bottom in such a way that a scour pool is formed.

Free logs: Logs or groups of logs that are not embedded, lodged or rooted in the stream channel.

Rootwad: The root mass of the tree.

Snag: A standing dead tree, or, a sometimes a submerged fallen tree in large streams. The top of the tree is exposed or only slightly submerged.

Sweeper log: Fallen tree whose bole or branches form an obstruction to floating objects.

Large Woody Debris Recruitment: The standing timber adjacent to the stream that is available to become large woody debris. Activities that disturb riparian vegetation including timber removal in riparian areas can reduce LWD recruitment. In addition, current conditions also reflect the past history of both natural and management-related channel disturbances such as flood events, debris flows, splash damming and stream cleanout.

Late-Successional Reserves (LSR's): A land management designation for federally-administered lands within the range of the northern spotted owl (USFS and BLM 1994). Late-Successional Reserves are managed to protect and enhance conditions of late-successional and old-growth forest ecosystems, which serve as habitat for late-successional and old-growth forest related species including he northern spotted owl. Limited stand management is permitted.

Limiting Factor: Single factor that limits a system or population from reaching its highest potential.

Macroinvertebrates: Invertebrates large enough to be seen with the naked eye (e.g., most aquatic insects, snails, and amphipods).

Mass wasting: Landslide processes, including debris falls, debris slides, debris avalanches, debris flows, debris torrents, rockfalls, rockslides, slumps and earthflows, and all the small scale slumping collapse and raveling of road cuts and fills.

Matrix: A land management designation for federally-administered lands within the range of the northern spotted owl (USFS and BLM 1994).   The matrix consists of those federal lands outside of the six categories of designated areas (Congressionally Reserved Areas, Late –Successional Reserves, Adaptive Management Areas, Managed Late-Successional Area, Administratively Withdrawn Areas, and Riparian Reserves).   Most timber harvest and other silvicultural activities would be conducted in that portion of the matrix with suitable forest lands, according to standards and guidelines. Most timber harvest takes place in the matrix.

Native: Occurring naturally in a habitat or region; not introduced by humans.

Non-Point Source Pollution: Polluted runoff from sources that cannot be defined as discrete points, such as areas of timber harvesting, surface mining, agriculture, and livestock grazing.

Oligotrophic: Pertaining to a lake or other body of water characterized by extremely low nutrient concentrations such as nitrogen or phosphorous and resulting in very moderate productivity.

Parr: Young trout or salmon actively feeding in freshwater; usually refers to young anadromous salmonids before they migrate to the sea. See *smolt*.

Plunge pool: A pool created by water passing over or through a complete or nearly complete channel obstruction, and dropping vertically, scouring out a basin in which the flow radiates from the point of water entry.

Productivity: A measure of habitat quality which varies by species and lifestage. Productivity is a density-independent measure of habitat quality. Examples include, water temperature, water discharge, channel complexity, riparian condition, etc.

Rain-on-snow events: The rapid melting of snow as a result of rainfall and warming ambient air temperatures. The combined effect of rainfall and snow melt can cause high overland stream flows resulting in severe hillslope and channel erosion.

Rearing habitat: Areas required for the successful survival to adulthood by young animals.

Recovery: The return of an ecosystem to a defined condition after a disturbance.

Redds: Nests made in gravel (particularly by salmonids) for egg deposition consisting of a depression that is created and the covered.

Rehabilitation: Returning to a state of ecological productivity and useful structure, using techniques similar or homologus in concept; producing conditions more favorable to a group of organisms or species complex, especially that economically and aesthetically desirable flora and fauna, without achieving the undisturbed condition.

Resident fish: Fish species that complete their entire life cycle in freshwater.

Riffle: Stream habitat having a broken or choppy surface (white water), moderate or swift current, and shallow depth.

Riparian: Pertaining to the banks and other adjacent, terrestrial (as opposed to aquatic) environs of freshwater bodies, watercourses, and surface-emergent aquifers, whose imported waters provide soil moisture significantly in excess of that otherwise available through local precipitation – soil moisture to potentially support a mesic vegetation distinguishable from that of the adjacent more xeric upland.

Riparian Area: The area between a stream or other body of water and the adjacent upland identified by soil characteristics and distinctive vegetation. It includes wetlands and those portions of floodplains which support riparian vegetation.

Riparian Habitat Conservation Areas (RHCA): Portions of watersheds where riparian-dependent resources receive primary emphasis, and management activities are subject to specific standards and guidelines. The RHCAs include traditional riparian corridors, wetlands, intermittent headwater streams, and other areas where proper ecological functioning is crucial to maintenance of the stream's water, sediment, woody debris and nutrient delivery systems (USFS AND BLM 1995/ PACFISH)

Riparian Reserves: A land management designation for federally-administered lands within the range of the northern spotted owl (USFS and BLM 1994/ Northwest Forest Plan). The Riparian Reserves provide an area along all stream, wetlands, ponds, lakes, and unstable and potentially unstable areas where riparian-dependent resources receive primary emphasis.

Riparian Vegetation: Terrestrial vegetation that grows beside rivers, streams and other freshwater bodies and that depends on these water sources for soil moisture greater than would otherwise be available from local precipitation.

Riprap: Large rocks, broken concrete, or other structure used to stabilize streambanks and other slopes.

Rootwad: Exposed root system of an uprooted or washed-out tree.

Run: An area of swiftly flowing water, without surface agitation or waves, which approximates uniform flow and in which the slope of the water surface is roughly parallel to the overall gradient of the stream reach.

SaSI (Salmonid Stock Inventory): A list of Washington's naturally reproducing salmonid stocks and their origin, production type and status.

SASSI (Salmon and Steelhead Stock Inventory): former name of SaSI.

SSHIAP (Salmon, Steelhead Habitat Inventory and Assessment Project): A partnership based information system that characterizes distribution and freshwater habitat conditions of salmonid stocks in Washington.

Salmonid: Fish of the family salmonidae, including salmon, trout chars, and bull trout.

Salmon: Includes all species of the family Salmonid

Sediment: Material carried in suspension by water, which will eventually settle to the bottom.

Sedimentation: The process of subsidence and deposition of suspended matter carried in water by gravity; usually the result of the reduction in water velocity below the point at which it can transport the material in suspended form.

Side channel: Lateral channel with an axis of flow roughly parallel to the mainstem, which is fed by water from the mainstem; a braid of a river with flow appreciably lower than the main channel. Side channel habitat may exist either in well defined secondary (overflow) channels or in poorly defined watercourses flowing through partially submerged gravel bars and islands along the margins of the mainstem.

Sinuosity: Degree to which a stream channel curves or meanders laterally across the land surface.   Can be determined by the ratio of the stream length to valley floor, or, the ratio of the channel length between two points on a channel to the straight line distance between the same points.

Slope: Water surface slope is determined by measuring the difference in water surface elevation per unit stream length. Typically measured through at least twenty channel widths or two meander wavelengths.

Slope stability: The degree to which a slope resists the downward pull of gravity.

Smolt: Juvenile salmonid, 1 or more years old, migrating seaward; a young anadromous trout, salmon, or char undergoing physiological changes that will allow it to change from life in freshwater to life in the sea. The smolt stage follows the parr stage. See *parr*.

Stock: Group of fish that is genetically self-sustaining and isolated geographically or temporally during reproduction. Generally, a local population of fish. More specifically, a local population – especially that of salmon, steelhead (rainbow trout), or other anadromous fish – that originates from specific watersheds as juveniles and generally returns to its birth streams to spawn as adults.

Stream Number: A unique six-digit numerical stream identifier, with the first two digits representing the WRIA and the last four digits representing the unique stream identifier from the WDF Stream Catalog (Williams et al. 1975) where available. For streams where the Stream Catalog does not provide a stream identified: (1) unassigned numbers in the sequence are used; or (2) an additional single-character alpha extension may be added to the end of the four-digit stream identifier for the next downstream numbered stream. Alpha extensions are generally used for tributaries to a numerically identified stream proceeding from downstream to upstream.

Stream Order: A classification system for streams based on the number of tributaries it has. The smallest unbranched tributary in a watershed is designated Order 1. A stream formed by the confluence of two order 1 streams is designated Order 2. A stream formed by the confluence of two order 2 streams is designated Order 3; and so on.

Stream Reach: a homogeneous segment of a drainage network characterized by uniform channel pattern, gradient, substrate and channel confinement.

Stream Types:

Type 1: All waters within their ordinary high-water mark as inventoried in "Shorelines of the State".

Type 2: All waters not classified as Type 1, with 20 feet or more between each bank's ordinary high water mark. Type 2 waters have high use and are important from a water quality standpoint for domestic water supplies, public recreation, or fish and wildlife uses.

Type 3: Waters that have 5 or more feet between each bank's ordinary high water mark, and which have a moderate to slight use and are more moderately important from a water quality standpoint for domestic use, public recreation and fish and wildlife habitat.

Type 4: Waters that have 2 or more feet between each bank's ordinary high water mark. Their significance lies in their influence on water quality of larger water types downstream. Type 4 streams may be perennial or intermittent.

Type 5: All other waters, in natural water courses, including streams with or without a well-defined channel, areas of perennial or intermittent seepage, and natural sinks. Drainage ways having a short period of spring runoff are also considered to be Type 5.

Subwatershed: One of the smaller watersheds that combine to form a larger watershed.

Supplementation: the collection, rearing, and release of locally adapted salmon in ways that promote ecologic and genetic compatibility with the naturally produced fish.

Terrace: Abandoned floodplain.

Thalweg: The path of maximum depth in a river or stream.

Watershed: An area so sloped as to drain a river and all its tributaries to a single point or particular area. The total area above a given point on a watercourse that contributes water to its flow.

Watershed restoration: Reestablishing the structure and function of an ecosystem, including its natural diversity; a comprehensive, long-term program to return watershed health, riparian ecosystems, and fish habitats to a close approximation of their condition prior to human disturbance.

Watershed-scale approach: Consideration of the entire watershed in a project or plan.

Weir: Device across a stream to divert fish into a trap or to raise the water level or divert its flow. Also a notch or depression in a dam or other water barrier through which the flow of water is measured or regulated.

Width-depth ratio: Describes the dimension and shape factor as the ratio of bankfull channel width to bankfull mean depth.

Wild Stock: A stock that is sustained by natural spawning and rearing in the natural habitat regardless.